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IMPLEMENTATION OF POLLUTION CONTROL MEASURES FOR URBAN STORMWATER RUNOFF

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and
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Editors

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CONTENTS

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INTRODUCTORY REMARKS

James Bishop

The topic under discussion, Pollution Control Planning reflects a serious need for environmental protection. Its initials, PCP, have a serious sound to them. At first glance you may think that you have misread yet another chlorinated compound that is out there threatening our lives. Not only is pollution control planning a serious topic, it is by its very nature an ambiguous topic.

Pollution control planning. Really, what is that? Is it something that we all do every time we put in a septic system in the cottage or if you plan where you are going to locate your privy if you don't have a septic system. All of this is pollution control planning and I guess all of us are doing it every day of our lives in the professions that we are in. The other gratifying thing about a turn-out this large is that we are not the only game in town today. At the same time that this conference is happening here, there is another one just up the road at the Constellation Hotel. It too has a made-in-Ontario acronym, SPOF (Strategic Planning for Ontario Fisheries). This is a program that MNR are bringing to the public for the first time today and they are attracting about an equal number of delegates ranging from industrial captains to indian chieftains to interest groups such as Green Peace and Pollution Probe. So they have a very mixed bag over there and there is also the World Dioxin Conference in town for the last couple of days. It is especially gratifying given that kind of competition to see this crowd here.

In the year since the first pollution control planning (PCP) seminar, held in Toronto on February 9-10, 1987, the Ministry of the Environment (MOE) has made many significant strides towards providing a better environment. It has released a comprehensive discussion paper on air pollution control, promoted improvements in waste management, and undertaken the ambitious task of developing regulations under the Municipal Industrial Strategy for Abatement (MISA) program to reduce and ultimately eliminate the release of persistent toxics in effluents discharged to our water environment. All of these programmes are being superimposed on some already good environmental control programmes in Ontario.

Ontario has some 400 water pollution control plants (WPCP) in operation throughout the province, 90% of which provide secondary treatment or equivalent. There are many thousands of miles of sewers conveying sanitary wastes to the treatment systems or providing the necessary conduits to carry storm water away from built-up areas for discharge to appropriate lakes, streams or rivers. These systems are proof positive of acceptable past programs and are a tribute to the record of achievement shown by engineers, scientists, and consultants, working with municipal and provincial government officials.

In spite of successes in the past, water pollution is still a major issue with new, emerging challenges. Ontario's programme in this area has become more complex and sophisticated as the province moves towards the control of toxics under the MISA programme.

Pollution control planning is not something new to us. It has been around for a long time. However, it has gone through and is continuing to go through some new phases and some things that are relatively new to all of us. It is largely because of the terrific increase in public interest in matters that deal with pollution and it is unavoidable and some will argue that it may be a very good thing to have the public to get actively involved in some of the technical things that we have to grapple with on a daily basis.

The public concern can sometimes be a little extreme as was the case in 1989 in Baie Comeau (with attempts to transport and store PCBs). The public tends to take information that is either marginal at best, sometimes false, regarding the seriousness of a problem like PCBs. However, it underlines the great concern they have got both with the obvious types of pollution around them like air pollution, smog, and placarded beaches and the more insidious and invidious and invisible types of pollution like that associated with heavy metals and chlorinated organics such as dioxins. Because of this increased complexity and increased public focus, it requires that all of us have a much more rigorous and technically unassailable approach to pollution control planning.

Technical excellence has to be a cornerstone of any of the work that we do. Looking at the papers presented in this book, we think that they exemplify that kind of excellence. We are really glad to see the quality of papers and topics that we have got.

A word or two about the pollution control plan. Everyone can have their own definition. It's like defining the difference between animals and man etc. I (JB) personally have

always liked Mark Twain's definition of the differences. Human beings are the only species that can blush and is the only species that has a need to. In general, when one is defining a pollution control plan, the place to start is to define the geographic boundaries of the problem you are dealing with, then, to identify the sources and the nature of the pollutants and to define the extent of the water quality problem. What exactly is the issue? Is the issue flooding basements, or something more insidious than that? Is it getting down to placarding beaches? It requires a thorough analysis of whatever facilities are in the area ranging from the collection system, pump houses, capacity, the actual operation of the sewage treatment plant itself.

It also requires that one has a well established and meaningful public participation program. I think that we are only now starting to get the hang of public participation at all levels of government: federal, provincial and municipal, We have to prepare remedial actions. We have to develop an implementation program for those actions, once we have vetted them through the public process and determined the allocation of public funds towards it and sometimes private funds. Then we actually have to do it and then to monitor how effectively it was, whatever it was that you did, so that you can apply that knowledge next time and avoid the mistakes. In that regard, we are very lucky to have people both in the municipal side and at the federal level who can share with us some of their experience and in particular, those from the United States who in some jurisdictions appear to be well ahead of the pack. It helps a lot to be able to share with them their successes and their failures.

Just a word or two about the rest of the topics covered in this book. The book describes the broad impacts of stormwater. Some of Ontario's approaches as determined through negotiations with our Ministry and Natural Resources are also covered but personal contact with staff is required to shed some light on the Byzantian relationship between those two ministries. The U.S. experience in trying to control and deal with CSOs and stormwater and the municipal implications are also covered In the last portion of the book, we deal with innovative technologies, and with some of the control strategies that may have worked and how they might apply to each of our individual situations. Finally the institutional context and its legal framework are described in several papers.

CHAPTER 1

Setting Objectives for Urban Drainage Design to Ensure a Healthy Ecosystem and Recreational Opportunities

B. Hindley

ABSTRACT

The purpose of this paper is to introduce broad concepts of ecosystem management and sustainable development to the issue of urban drainage planning and stormwater quality control. The paper argues that the current approach to urban drainage planning remains largely driven by human safety concerns and protection of property (flood and erosion control), and to facilitate municipal servicing and subdivision design needs without giving equal consideration to aquatic and riparian ecosystem values and passive recreation needs.

Stormwater runoff control measures currently focus on meeting regulations and standards such as controlling peak flows to predevelopment levels, on providing sufficient settling time for suspended solids and bacterial removal and on reducing nutrient and metal concentrations in storm sewer outfall discharges to arbitrarily set standards. This approach does not take account of the physical and chemical needs of aquatic organisms and their habitats, although it has been suggested that such measures, applied watershed wide, will provide adequate protection for aquatic resources. In particular, water quality objectives do not fully integrate the life cycle needs of an ecosystem symbol, for example a brook trout, which also include water flow rates and physical habitat features. If the ecosystem symbol's needs are not met, then the ecosystem is not healthy.

Using examples from the Rouge River Watershed Management Strategy undertaken by the Metropolitan Toronto and Region Conservation Authority, the paper suggests first setting objectives for a healthy ecosystem, with representative ecosystem types, whose physical and chemical needs can then be described and used to develop specific criteria for stormwater runoff control, subdivision design and long range landuse planning.

CHAPTER 1

1.1 Purpose of This Paper

The title of this seminar is "Implementation of Pollution Control Measures for Urban Stormwater Runoff". The purpose of pollution control measures is to provide adequate protection for aquatic life and water-based recreation. However, Figure 1 may be typical of the way in which these pollution controls get implemented. The government is happy, the developer and the consultant are happy, but what about the fish or the new home owner?

The purpose of this paper is to discuss urban drainage problems according to the "big picture", by introducing the principles of ecosystem management and sustainable development, and suggesting how these concepts may be applied to deal more effectively with urban drainage.

The MTRCA's Comprehensive Basin Management Strategy for the Rouge River Watershed (ROUGE study) (MTRCA, 1989) is a prototype example of setting ecosystem targets on a watershed basis and using these to seek integrated solutions to resolve land use impacts on flooding, erosion, water quality, fisheries and other environmental concerns. The ROUGE study provided detailed basin specific policies and an integrated implementation plan to enable water management agencies to chart a new course for the Rouge watershed, towards a healthy ecosystem state. This was made particularly challenging since the development of the plan was accomplished with the active participation of a stakeholders committee consisting of provincial and municipal agencies, and non-government organizations such as the Save the Rouge Valley System and the Urban Development Institute. Examples from this study are provided to illustrate this ecosystem approach.

1.2 Defining Targets to Maintain a Healthy Ecosystem

1.2.1 The Evolution of Water Management and Planning

In the last twenty years, we have seen an evolution of techniques to control flooding and erosion (water quantity controls) from traditional trapezoidal channels lacking any consideration for aquatic ecosystems, to the point now where "natural channel design" is gaining acceptance as a means of merging flood and erosion protection with aquatic and riparian habitat rehabilitation.

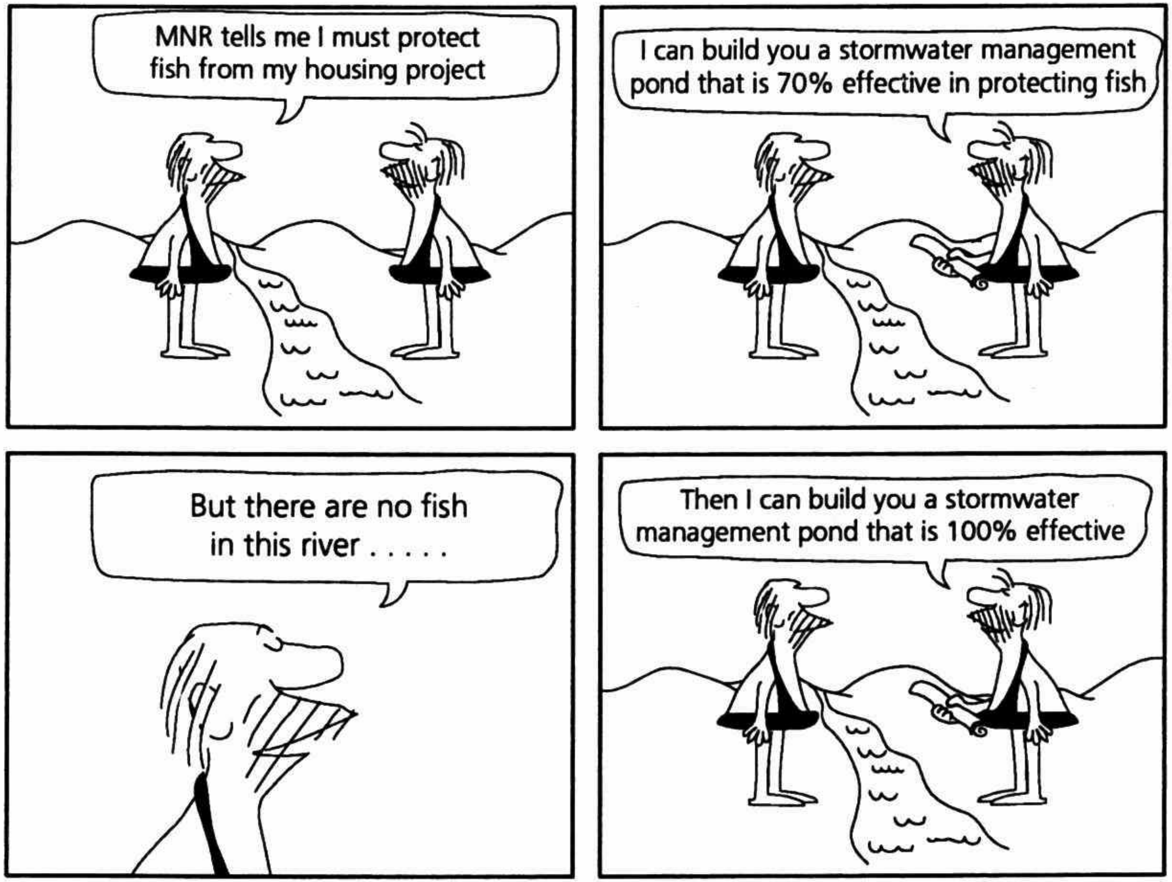


Figure 1: Cartoon of Happy Society and Fish

Now we are ready to tackle pollutants in urban drainage, and there is some concern that the environmental sensitivity gained from two decades of quantity control may be ignored. With today's recognition by the public of environmental values, and international and national task forces on sustainable development, we cannot afford to do this.

Our experience from the ROUGE study is that flooding, erosion and public health issues are best dealt with according to three zones within a typical watershed:

- intermittent watercourses less than 130 ha.
- first, second and third order watercourses generally less than 5000 ha.
- larger order watercourses.

New recommended policies in each of these areas provide greater flexibility in dealing with flood and erosion problems than previously, and recognise the potential to deal with environmental and water quality issues in a more integrated fashion.

1.2.2 Ecosystem Management and Sustainable Development

Ecosystem management and sustainable development argue for a novel way of thinking for urban drainage planning by rephrasing the question before coming up with answers. Instead of "how can we best mitigate the effects of urban runoff on watercourses", we should ask "what are the essential characteristics of the aquatic (and riparian) ecosystem and how can they be maintained and enhanced through urban drainage, land use and watershed planning?".

Vallentyne and Hamilton (1987) describe four approaches to resolving man-made ecosystem problems; these could also be viewed as evolutionary steps in our approach to urban drainage planning.

- egosystemic - man at the centre or "me first"
- piecemeal - single problem solutions
- environmental - "green" solutions: mitigation and "wise use"
- ecosystemic - ecosystem first: natural resources are shared with other life forms

POLLUTION CONTROL IMPLEMENTATION

Table 1 shows some examples of typical man-made ecosystem problems and their solution under these different approaches.

How would these approaches deal with the problem of urban drainage?

egosystemic:	concrete channel (convenience and flood control), combined sewer system with overflows, fish elsewhere
piecemeal:	increase channel size, separate sewers, stock fish
environmental:	stormwater management facilities (retention, detention) development controls water quantity/quality standards route stormwater to Water Pollution Control Plant (WPCP)
ecosystemic:	water conservation natural channel design design with nature setting targets for healthy riparian and aquatic habitats and marketing these as attractive community features risk management

The idea of identifying the essential characteristics of an ecosystem is not an easy one and is often an unpalatable one for "developers" and "naturalists" alike. Developers often view such a process as setting unrealistic and unattainable objectives - as one fellow once suggested "its like trying to go back to the 16th century.". Naturalists, on the other hand, are also apprehensive about setting criteria that are too low and often would prefer that the ecosystem be "left alone" by putting 300 m buffer zones and "no trespassing" signs around the ecosystem to be protected. Indeed it is difficult to describe an ecosystem as a photograph when it is really a feature film.

The Brundtland Commission (1987) and the National Task Force on Environment and Economy have called this ecosystem approach to problem solving SUSTAINABLE DEVELOPMENT. The essence of the concept of sustainable development is planning for change to ensure that use of natural resources today does not impair their potential for use by future generations. Sustainable development requires planning that acknowledges ecological boundaries, not only societal ones.

TABLE 1: COMPARISON OF FOUR APPROACHES TO RESOLVING MAN-MADE ECOSYSTEM PROBLEMS (Vallentyne and Hamilton, 1987)

problem	Egosystemic	Piecemeal	Environmental	Ecosystemic
Transmission of disease	Causes unknown	Conduits pills	Curative	Preventive, rehabilitative
Organic waste	Hold your nose	Discharge downstream	Reduce BOD	Energy recovery
Eutrophication	Mysterious causes	Discharge downstream	Phosphorus removal	Nutrient recycling
Acid rain	Unaware	Not yet a problem	Taller smokestacks	Recycle sulfur
Energy shortages	Hunt a scapegoat	Increase supply	Expand grid	Inverted rate schedules
Toxic chemicals	Unaware	Not yet a problem	Discharge permits	Design with nature
Greenhouse effect	Unaware	Not yet a problem	Sceptical analysis	Carbon recycling
Pests	Run for your life	Broad spectrum insecticides	Selective degradable poisons	Integrated pest management
Traffic congestion	More roads	More superhighways	Staggered hours	Public transport, decentralize
Demotechnic growth	Unaware	Measure it	Zoned development	Conserver society
Attitude to nature	Indifferent	Dominate	Cost/benefit	Respect
View of future	Egocentric	Linear, predictable	Wary	Emergent, evolving

POLLUTION CONTROL IMPLEMENTATION

In a recent MNR strategic planning document (MNR, 1989), sustainable development was defined as follows:

- Sustainable development is the integration of environmental and economic factors in resource management decision-making. It goes beyond the concepts of balancing, trading off or mitigating measures. It involves a recognition that a decision about development is a rational, economic one only if it includes all the factors, short-term and long-term, about the environmental consequences of the decision, and the interdependence of the effects. It is the upfront recognition and comprehensive assessment of ecological, social and economic factors throughout all facets of policy, planning, program development and operations. In any specific instance, the end result may be a decision favouring more protection, or more exploitation, or something in between. However, the decision-making process itself would be an integrating process that gives full consideration to all relevant factors at all stages.

- The first objective of sustainable development is to ensure that protection of environmental factors are on the same footing as economic development factors and that both sets of factors will be considered comprehensively in managing the resource base wisely, on a sustainable basis. It asserts a compatibility between environmentally sound decisions and long-term economic health, in contrast to a view that presupposes a choice between conflicting objectives.

How can we incorporate sustainable development or an ecosystemic approach to problem solving in urban drainage planning?

From the ROUGE study, here are some sustainable development and ecosystem management principles at a watershed scale:

- the watershed is the basic ecosystem planning unit, and its management must also benefit larger ecosystems of which it is one part (eg. the Great Lakes ecosystem)

- every watershed has broad physiographic features (eg headwaters, tablelands and valleys, rivers and estuaries) which are distinct, but inseparable planning units in ecosystem management

- environmental, social and economic values must be fully integrated through the decision-making process in planning for sustainable development of the watershed

- ecosystem values must be clearly understood and shared by everyone in the watershed and all management agencies must work cooperatively toward their achievement

- the basin management plan must have the following characteristics:

  - it must establish ambitious yet realistic goals based on an ecosystemic planning approach
  - it must demonstrate to all stakeholders their role and function, and the importance of implementing the plan as a team
  - it must be a living plan that determines and initiates implementable measures immediately but also provides flexibility for more innovative measures in the future
  - it must be a living plan that can be continually reviewed and improved to take full advantage of technological advancements in planning for sustainable development
  - it must chart a new course for the watershed as an ecosystem planning unit away from degradation towards conservation, enhancement, rehabilitation and restoration (Figure 2). This direction of actions will bring the watershed ever closer to a healthy ecosystem state and away from gradual degradation, while still providing opportunities for economic growth and development

Now, how can we take these lofty principles and interpret them into guidelines for stormwater runoff control?

1.3 What are the Ecosystem Zones of a Watershed Ecosystem?

The Rouge watershed represents a good example of a typical south-central Ontario watercourse. A watershed ecosystem implies that its components are water-based not only land-based, with land surfaces then divided according to the watershed network of headwater recharge areas, streams, tributaries, rivers and wetlands. Water is also the

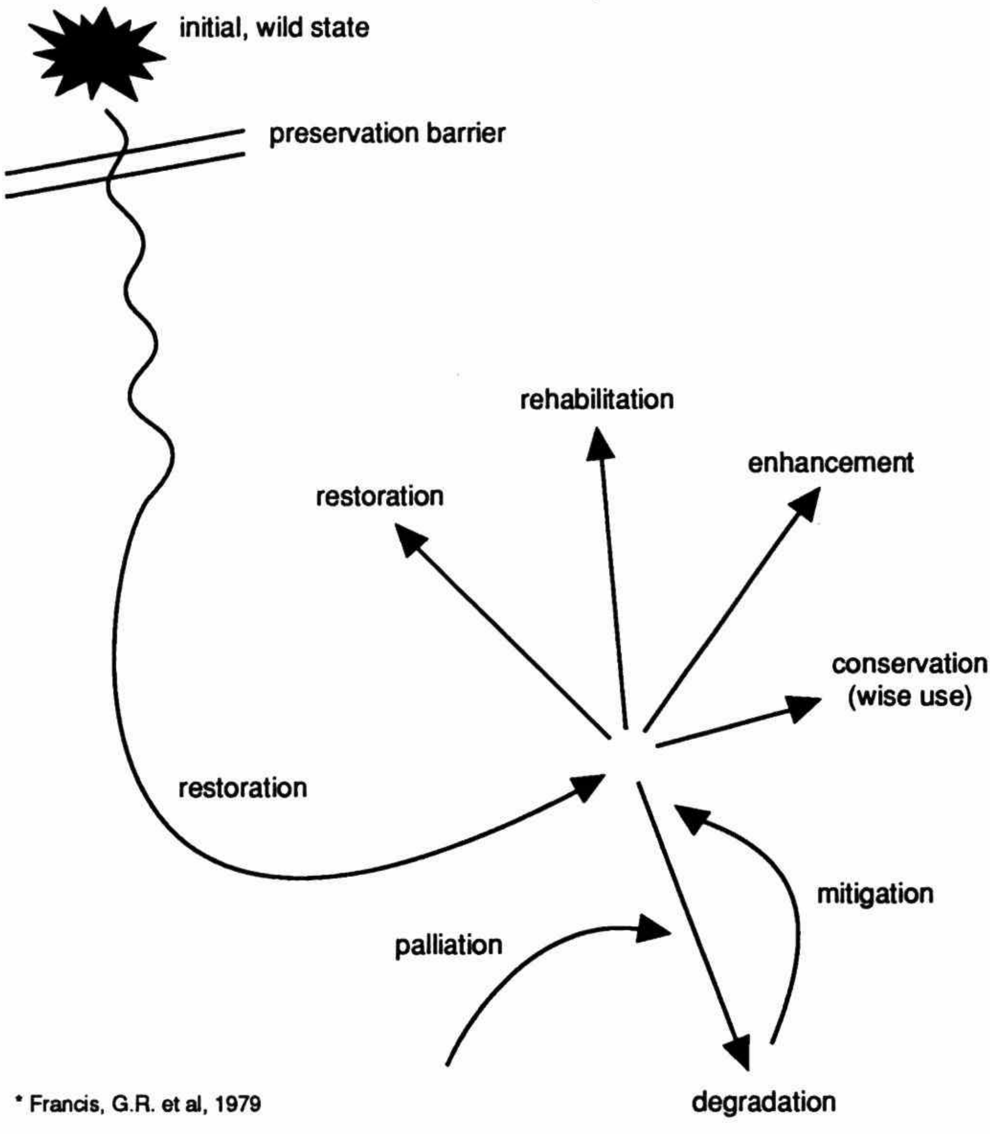


Figure 2: Ecological Course of Action

logical and natural integrator of the varied resources in the watershed: most natural systems depend on water to cycle energy, nutrients and essential elements through the ecosystem and water is the predominant driving force behind most physical and chemical processes.

A river ecosystem is often regarded as an ecosystem continuum since it represents, at any given time, a succession of ecosystem types from headwaters to mouth. Generally in Southern Ontario, these can be broken into the following zones:

headwaters: steep gradient, permanently flowing, first and second order streams. Groundwater is the predominant source of flow and topography is rugged to undulating, often dissected with many areas of internal drainage. The stream channel is well defined with poorly developed sinuosity and an ill defined valley - e.g. moraine streams.

mid-reaches: shallow gradient, third or fourth order streams. Surface water becomes the predominant source of flow (or at least the dominant flow that alters the physical characteristics of the river). The topography is flat to gently rolling and the stream channel is defined, but highly sinuous (meandering) with steep unstable banks - e.g. Peel plain streams.

lower reaches: moderate gradient, fourth, fifth or greater order rivers. The upstream drainage network is the major source of flow. Topography is flat to undulating tablelands with broad, steep sloped river valleys. The stream channel is well defined and moderately sinuous within a wide valley. The channel may be braided with side channel or ox-bow lakes. The gradient break between mid and lower reaches may be sharply defined - e.g. lower Rouge river

delta marsh: the interface between river and lake. A broad river valley often dissected with water areas cut off from the main channel. The mouth typically ends in a bay-mouth bar formation formed by lake wave action. Valley walls still well defined but lower and not as steep, merging with lake shoreline features (bluffs and beaches) - e.g. Rouge marsh.

intermittent streams:	defined generally as watercourses which do not flow year round or perhaps which freeze to the bottom in winter. These occur throughout the watershed; in the ROUGE study, they were defined as draining less than 130 ha. (otherwise the West Humber River could be considered as an intermittent stream). These are characteristically drainage swales, temporary wetlands, generally low lying, interconnected areas of topography. They are natural channels created by rain or melt waters running off the land.
areas of internal drainage:	drainage areas such as swamps, marshes, wetlands, kettle lakes, etc. with no surface connection to water courses. These are often more common in headwaters and are regarded as important recharge areas for aquifers.

The remaining "zone" is the tableland which can be defined as flat lands outside the valley lands. The tablelands within a watershed can be categorized according to the river ecosystem zone to which they drain, and in this way they become an integrated part of the river ecosystem continuum.

In the ROUGE study, these river ecosystem zones were called "water course impact zones" because each zone responded differently to land use impacts (see Figure 3).

In addition, lands can be defined in terms of terrestrial ecosystem types which usually are not bounded by water e.g. forest communities, grasslands, white-tailed deer ranges. In southern Ontario, these terrestrial communities are usually fragmented or lost since they come into direct competition for space with man. All that often remain in a rural or urban area are woodlots, valleys and some forested headwaters.

1.4 What is a Healthy Ecosystem?

Having established these ecosystem zones in the ROUGE study, the next step was to describe the biological community associated with each, both terrestrial and aquatic. At this point in the study, there were conflicts among the ROUGE stakeholders regarding what the biological components of a healthy ecosystem are in each of these zones.

STREAM LEVEL	FLOOD/EROSION CONTROL	FISHERIES
Level 1 (L-1) (micro system)	- intermittent flows - generally pipes, swales and ditches	- Level 1 - supports downstream fisheries habitat - water quality - temperature - turbidity - dissolved oxygen
Level 2 (L-2) (tributary system)	- defined low-flow channel - continuous flow	- Level 2A Brook Trout (Moraine and Moraine Influenced Watercourses) - Level 2B Bass
Level 3 (L-3) (river system)	- principal watercourse	- Level 3A Bass - Level 3B Rainbow Trout
Level 4 (L-4)	- river mouth influenced by Lake Ontario	- Level 4 - Bass, Pike (Lacustrine Marsh)

Figure 3: Watercourse Impact Zones

POLLUTION CONTROL IMPLEMENTATION

The ROUGE study defined the healthy ecosystem in each zone on the basis of an organism, plant or species grouping that symbolizes a healthy ecosystem in a way that people can understand and identify with (there are a host of other criteria that a symbol should have , but these two are key). For example, if a stonefly was used as the symbol of a healthy headwater ecosystem zone, it would be true, however, only a few fly fishermen could picture the ecosystem type. On the other hand, if a brook trout was used as the ecosystem symbol, most people would picture a small, cold, clear brook with riffles and pools and heavily treed banks. The brook trout was not selected as a symbol because of its value to man, rather because it has the combined attributes of being well known to man as well as a sensitive representative of an ecosystem type; a symbol of a healthy ecosystem. Christie et. al. in their paper "Managing an ecosystem like a home", further suggest that providing we see the "home" of the symbol as the whole ecosystem not just the symbol or "head of the house" it is possible to effectively restore the ecosystem to health even though the symbol is not currently there (i.e. the brook trout has disappeared due to habitat degradation).

In a degraded watershed, the challenge is in selecting what the healthy ecosystem should be and what ecosystem symbol should be used. Choices among ROUGE study stakeholders fell somewhere between the ecosystem that is there now versus the ecosystem that was historically there.

For example, many Lake Ontario tributaries once supported anadromous Atlantic salmon and brook trout. Today we have no more Atlantic salmon, and our streams may contain brook trout, a mix of anadromous trout and salmon, large and small mouth bass, pike, longnose dace and creek chub, carp or sometimes no fish at all.

The following ecosystem symbols were selected for each of the ecosystem zones in the Rouge:

headwaters	brook trout
midreaches	smallmouth bass
lower reaches	rainbow trout
delta marsh	smallmouth bass, pike

On the Little Rouge River, based on stakeholders recommendations, rainbow trout were chosen for the midreaches rather than smallmouth bass.

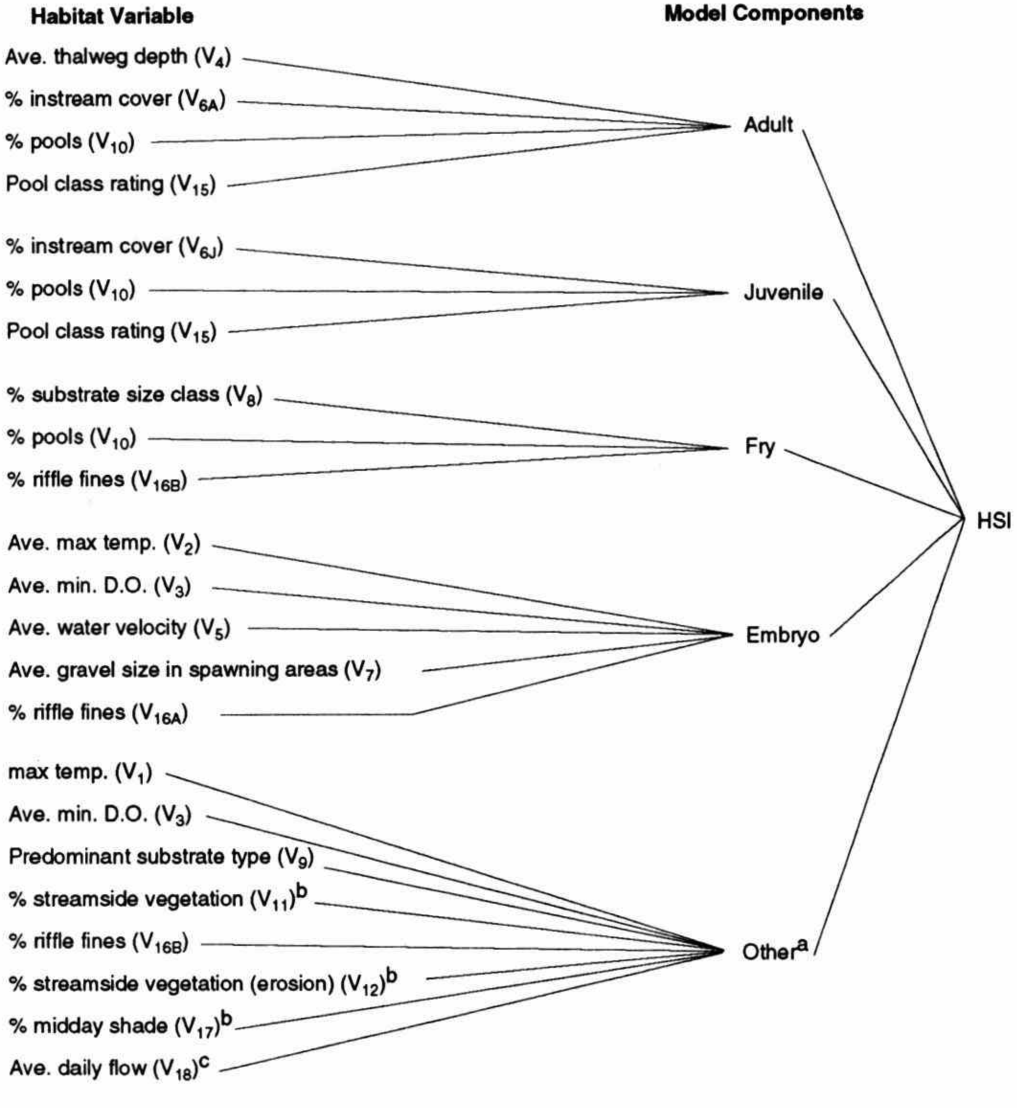
In the United States, a series of models (e.g., Edwards *et al.*, 1983; U.S. FWS, 1980) have been developed called Habitat Suitability Indices (HSI) for various species of fish and wildlife (Figure 4). These HSI's attempt to use our knowledge of the habitat requirements of a species throughout its life cycle to develop rating criteria that integrate quality, quantity and habitat variables. These can be used to evaluate existing conditions and identify rehabilitation priorities. HSI's for several fish species have an added feature in that vegetated parts of riparian habitat characteristics form part of the overall HSI rating for these species.

HSI's do not provide all the answers, but they are a step in the right direction because:

- they provide an evaluative and priority setting tool for ecosystem identification and rehabilitation.
- they attempt to integrate physical, chemical and habitat requirements of a species and its associated ecosystem.
- they define deficiencies in both the aquatic and riparian components of ecosystems.
- they provide a more objective means of identifying the type and structure of an ecosystem.
- they provide opportunities to evaluate innovative remedial or rehabilitative measures.

There is no question that the ecosystem symbols set for the Rouge can be used to establish healthy ecosystem zones in a river ecosystem continuum: but are they the right ones?

While there is not a good answer for this, it is a step in the right direction. Each ecosystem zone in the Rouge has suffered a series of historic human abuses over time to the point where it is likely unrealistic to expect to return to that forested, unsettled watershed of over 200 years ago. The ROUGE study attempted to set objectives for healthy ecosystems that may realistically be achieved in the next several decades and acknowledged that, providing flexibility is built into rehabilitative measures, these



[a] Variables that affect all life stages
[b] Optional variables
[c] Steelhead variable

Figure 4: Diagram Illustrating the Relationship Among Model Variables, Compounds and HSI

objectives could be reviewed and revised to further improve the ecosystem as our technology to do this develops. This approach would seem to be consistent with sustainable development.

The ROUGE study did not tackle setting ecosystem symbols for intermittent streams other than to indicate that water quality and quantity from these areas must support downstream ecosystem types. Likewise, no symbols were set for areas of internal drainage other than to acknowledge that environmentally significant areas studies and wetland evaluations were required to determine how they should be dealt with. MNR, MTRCA and some municipalities have policies in this regard. This is where some of the most challenging issues are in terms of urban drainage.

What ecosystem symbol is most representative of a healthy ecosystem in these cases? These are perhaps best dealt with as features of urban (and rural) design: the challenge to water resource managers is to convince landowners and developers to see these features as attractive "greenscapes" or "bluescapes" within housing developments and industrial complexes instead of nuisance topographic features to be filled, graded or piped.

1.5 Are Human Recreation Values in Conflict With Ecosystem Values?

Christie et.al. note that if we treated natural ecosystems as interconnected systems, as important to our welfare as to the welfare of other organisms and dealt with our impacts on ecosystems in an anticipatory and ethical way (like we treat our neighbours, ideally), then mankind would become the healthy ecosystem symbol. Unfortunately human interactions with natural ecosystems tend to be competitive, consumptive or abusive. Sustainable development argues for coexistence. Currently most human activities compete directly with natural terrestrial ecosystems for the land base or are consumed by man as food or raw materials. Man's activities impact directly on water as well, but often it is the indirect water impacts that result in reduced water supplies for natural systems through consumption, waste disposal, contamination, diversion and habitat destruction.

What about passive recreation values: are these in conflict with natural ecosystems? While swimming is passive, high bather densities result in erosion and siltation and increase harmful bacteria levels in water. There is a point where swimming ceases to be "passive" recreation and ceases to coexist with the natural ecosystem. Many who have viewed

hordes of fishermen crowding the shores of rivers with spawning migrations of trout and salmon would agree that this intensity of fishing is no longer "passive" either.

Still, setting values for these passive recreational uses in our watersheds can symbolize healthy ecosystems in the same way that brook trout do. Fishing and swimming are human measures of a healthy, natural ecosystem. Scenic lookouts, unobstructed natural horizons, clear waters without surface films or "objectionable floatables" are others.

We use fecal coliforms as an indicator of the presence of organisms that endanger human health although arguments still rage as to whether they do. The ROUGE study used fecal coliform criteria as a desired human health standard throughout the river although it was recognised that public bathing occurred or was likely to occur in only a few areas. This leads to the possibility that it may be as useful to consider fecal coliforms as indicators of the degree to which humans and domestic animals impact on the watercourse, and set a fecal coliform standard based on some acceptable level that would symbolize a healthy ecosystem whether or not contact water recreation occurs. This may provide a better rationale for controlling fecal coliforms in stormwater runoff than constantly trying to relate these standards to risks to human health or existing bathing areas.

More creative use of recreation standards, aesthetic values and HSI's as healthy ecosystem symbols may promote more ethical treatment of urban drainage issues than the symptomatic, fragmented approach that is often used now. More importantly, identifying these upfront will set clearer, integrated water resource management targets for government, developers and interest groups to work toward.

1.6 What are Some Ecosystem Solutions to Urban Drainage?

Given our set of ecosystem zones and healthy ecosystem symbols, how can rural, urban and urbanizing land use activities incorporate these values instead of mitigating them? The solution is to deal with these values at the same time that economic and social values are dealt with, at broad planning and conceptual design stages: in sustainable development jargon, putting ecosystem values on the same footing as economic ones and not prejudging the end product.

However, this is not an ideal world and there are few, if any watersheds where we have the luxury of preplanning the entire land base. Rural, urbanizing and urban abuses already exist and funds for total rehabilitation are hard if not impossible to raise. So symptomatic solutions are still necessary to deal with these existing problems. There are many innovative solutions to mitigate urban drainage problems now, that are a combination of structural and non-structural measures. It is important that in our rush to regulate stormwater quality controls, we do not preclude or discourage use of some of these new technologies which may enhance the ecosystem in other ways. Many of these are documented by the Metropolitan Washington Council of Governments Manual (Schueler, 1987) on controlling urban runoff through planning and design of urban best management practices.

Here are a few suggestions that begin to take an ecosystem approach by treating the problems not the symptoms **(having of course, first set ecosystem targets as outlined above using ecosystem symbols, HSI's, etc.):**

- the ROUGE study called for aggressive public programs of valleyland acquisition, stream and riparian habitat rehabilitation, and private land stewardship to improve existing ecosystem conditions

- match urban densities and land use types with drainage control needs - e.g. low density, high density and industrial developments may provide the greatest opportunity to preserve natural topographic features and the most potential for source controls

- encourage developers to market greenscapes, bluescapes and natural ecosystem features of their properties rather than destroying them - there is a willing group of environmentally conscious buyers

- look for innovative solutions to urban drainage (including revisiting some old ones) - reduce drainage to streets, provide overland drainage from streets, use infiltration devices, use landscape materials other than grass, consider street storage, cisterns

- require developers to work with existing topography and use areas of internal drainage as aquifer recharge zones

- use innovative storage and infiltration devices wherever possible in new, existing or redeveloping areas

- encourage water conservation to reduce water wastage, pollutant loads and waste assimilation needs. Consider using stormwater as a source of irrigation

- use land use restrictions such as maximum lot densities, maximum allowable impermeable surfaces, set ratios for impermeable surfaces/ infiltration trench areas to direct urban designers towards more sustainable solutions

- require preconstruction fencing

- require not only natural channel design but design with nature

- encourage municipalities to accept and developers to include more publicly owned lands in urban areas - there is a need to market the value to the public of smaller lots and more open space

- establish watershed capacities for development as a means of encouraging more sustainable development i.e. the capacity cannot be exceeded unless it can be accomplished in a sustainable way and perhaps not before some level of ecosystem rehabilitation is achieved. Incentives such as a density bonus in exchange for rehabilitating ecosystems, will help to promote technology development and innovation

- target urban fringe lands for rehabilitation and require landowners to correct existing problems prior to having their development proposals considered - encourage investments in greenspaces

This list is not intended to be exhaustive nor necessarily to offer the best solutions: rather it is a group of ideas that represent a more integrated and sustainable way of thinking than is currently practised in Ontario.

Hopefully this rather simplistic attempt at reviewing an ecosystem approach to a local problem such as urban drainage and stormwater runoff control is a useful starting point in trying to define how sustainable development can be applied locally.

Unless we set clear ecosystem targets and educate the development industry to the marketing value of retaining healthy water based ecosystem features, we may achieve some level of water quality protection but we will continue to degrade our urban watercourse ecosystems.

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CHAPTER 2

Proposed (1989) Interim Stormwater Quality Control Guidelines

Dale Henry

ABSTRACT

A draft document dealing with the control of stormwater runoff quality from new developments was developed over the period 1987-1989 jointly by two provincial ministries (Environment and Natural Resources). The draft document is entitled "MOE/MNR Interim Stormwater Quality Control Guidelines for New Development". It described the rationale, water quality requirements and implementation procedures to provide protection for our surface receiving waters.

The guidelines concentrated on the control of suspended solids and bacteria in storm water. Control measures and design requirements for the pre-construction, construction, and post-construction phases were outlined. Special emphasis was placed on developing areas where stormwater has the potential to impact waterbodies with recreational body contact uses and/or existing potential cold water fisheries. This emphasis included control of a specified volume of runoff, buffer strips and erosion and sediment control during construction.

This paper summarizes the key features of the guidelines as developed by the end of 1989 (Editors' Note). These guidelines have since been modified and updated in light of new knowledge and increased societal concern for protection of the environment. The guidelines as originally developed in 1989 are summarized in this chapter of the book with the intention of providing the reader with background to the subsequent version which is presented in the next chapter. Subsequent concepts have eliminated the priority one and priority two receiving water objectives to be more end use specific (e.g., coldwater, warmwater fishery and additional use objectives). This provides for increasing flexibility in application of the objectives to the potential myriad of water quality objectives applicable to the different surface waters and groundwater resources found within the Province of Ontario which are potentially degraded by urban land uses. The most recent version of the guidelines is presented in their entirety in Chapter 3.

CHAPTER 2

2.1 Background

During the 1980's, Southern Ontario experienced a large expansion in urban development. A major part of this urbanization occurred in the Greater Metropolitan Toronto area. With this growth came an increasing workload in the review of Plan of Subdivision applications by municipalities and provincial agencies including the Ministries of Environment (MOE) and Natural Resources (MNR). In addition, concern was raised by these and other offices on the impact of stormwater runoff on natural receiving waters and how to address this impact.

During the summer of 1987 a working committee was established to develop guidelines to address the concerns of stormwater runoff from new development. This resulted in the preparation of a draft document entitled "Interim Stormwater Quality Control Guidelines for New Development" by the "Ministry of the Environment and Ministry of Natural Resources". By the summer of 1988 the document had received internal review by both the Ministries of Environment (MOE) and Natural Resources (MNR). During late 1988 and through the first 9 months of 1989 the document was reviewed and commented upon by professionals in academic institutions, consulting and municipal engineering functions, and other agencies including the Ministries of Transportation, Municipal Affairs and Housing. It was anticipated that the document will be finalized in 1990. [The guidelines have since been updated but are still considered interim in 1992 - Editors' note.]

2.2 Rationale for Stormwater Quality Control

Traditionally, stormwater runoff has ranked as a low priority for water quality management. More recently, it has been determined that without adequate control, stormwater discharges to receiving waters are a significant source of water pollution. Stormwater runoff can stress and disrupt aquatic life and its habitat, and degrade recreational use areas. Illustrations of this stress and disruption are apparent in the Humber, Don and Rouge Rivers of Metropolitan Toronto area and in cities such as St. Catharines and Peterborough where Pollution Control Plans have been developed (Canviro, 1989; Paul Theil/BEAK, 1989).

During the construction phases of development, the erosion and loss of sediment during rain events increases significantly compared to the pre-development condition. This increase can result in the loss of valuable topsoil and other subsoils from the developing area. It increases the subsequent sedimentation of rivers and lakes. Sediment

accumulation can impact water supplies, flood control, fishing, navigation and recreational activities (GOUDIC, 1987). The suspended solids in the stormwater are particularly harmful in receiving waters supporting fisheries because of the resulting turbidity, siltation and the pollutants adsorbed to the solids which may accumulate in benthic organisms (Ellis, 1986).

The loss of sediment still occurs after the completion of the construction phase, although it is considerably reduced. Average pollutant concentrations reported by a number of investigators for fully developed areas are presented in Table 1. Intermittent spills to the stormwater sewers may also contribute independently to elevated pollutant concentrations, or to toxic effects to key aquatic organisms.

Stormwater from developed areas also contains high densities of bacteria and impacts the recreational use of the receiving water. Fecal coliforms are the prime indicator bacteria used in evaluating the health risk of bathers. Fecal coliforms can indicate the presence of pathogenic organisms which can cause minor skin irritations, ear, eye, nose and throat infections and dysentery, typhoid and cholera (DOE, MOE, 1978, 1980).

High nutrient concentrations from stormwater can cause excessive growth of aquatic plants and algae. This growth may result in depletion of dissolved oxygen in small lakes during summer stratification or under ice. Excessive dissolved oxygen depletion may cause fish kills or stress the fish community at less critical levels.

Toxic heavy metals (e.g., copper, zinc) or synthetic organic chemicals (SOCs) and high temperatures may severely impact the fish community's ability to reproduce and may prove lethal. Although metals remain largely insoluble and tend to accumulate in the sediments, copper, lead, zinc and cadmium can be dissolved under certain conditions and become toxic to some aquatic organisms (DOE, MOE, 1980).

Other metals such as mercury methylate, especially in sediments and bioaccumulate in fish, posing a hazard to man's health. Organic chemicals discharged from various sources including stormwater, also bioaccumulate in fish.

TABLE 1: WATER QUALITY CHARACTERISTICS OF URBAN STORMWATER RUNOFF

Parameter	USEPA* December 1983	Kronis, H March 1982	Droste, R.L. & J.P. Hartt 1975	Paul Theil Associates 1989	Novak, Z. & B. Whitehead June 1983	Frank, D., D. Henry, T. Chang & B. Yip August 1985
Suspended Solids (mg/L)	300	281	300	85	190	184
Biological Oxygen Demand (mg/L)	15	14	15	-	14	-
Chemical Oxygen Demand (mg/L)	140	138	150	-	-	-
Total Phosphorus (mg/L)	0.70	0.48	1.60	0.38	0.48	0.44
Soluble Phosphorus (mg/L)	0.21	0.06	0.80	-	-	0.083
Total Kjeldahl Nitrogen (mg/L)	3.30	2.20	-	1.65	-	2.30
Total Copper (mg/L)	0.093	0.050	-	-	-	-
Total Lead (mg/L)	0.350	0.570	-	-	-	-
Total Zinc (mg/L)	0.500	0.330	-	-	-	-
Fecal Coliforms	-	-	12,000	24,000	-	-

* Site median Event Mean Concentration (EMC) for 90th percentile Urban Site (/100 mL)

2.3 Objective and Purpose of Proposed Stormwater Quality Control (1989) Guidelines

The objective of the guidelines is to preserve the existing and potential uses of waterbodies whose quality may be adversely affected by new urban development. Specific guidelines have been developed for receiving waters which support either cold water fisheries or body contact recreation.

The purpose of the document is:

a) to provide guidance to staff of the Ministry of the Environment and Ministry of Natural Resources in the review of planning documents and development proposals and requirements for approval of stormwater management facilities for water quality control for new developments.

b) to provide guidance to municipalities and proponents for stormwater management for water quality control.

This document is intended to be reviewed and updated on an ongoing basis (editors' note: a subsequent update is provided in Chapter 3 of this volume).

2.4 Control Requirements Enunciated in the Guidelines

The guideline provided in the 1989 draft document was based on whether or not the receiving water supported cold water fisheries (or potential) and body contact recreation. **Priority One** areas were defined as areas where stormwater from new urban development had the potential to impact waterbodies with recreational body contact uses or existing/potential cold water fisheries. These waterbodies were considered extremely susceptible to an impact from stormwater runoff.

(Editors' note. The 1989 document considered either the protection of a cold water fishery or the protection of a receiving water body as "swimmable" interchangeably with "fishable for a cold water species". The 1991 version of the guidelines considered the "cold water fishable" management objective as distinctive from the "swimmable objective".)

All new developments in Priority One areas (except Consents) were required (1989 guidelines; editors' note) to have at least three items during the pre-construction and construction phase.

a) A construction-phase, stormwater management plan must be developed which addresses both water quantity and quality concerns.

b) Buffer strips and setbacks with a minimum of 30 horizontal metres of land from the receiving water must be retained with natural vegetation. Where no vegetation is present due to past land management practices re-vegetation will be required. Increases or decreases in the width of buffer strip may apply under certain conditions. (Editors' note. The vegetative buffer strips were included as a major method for protection of the habitat of resident cold water species of fish due to Bette *et al.*'s evidence that 5 km of riparian overhanging vegetation maintain conditions appropriate for a resident cold water fishery in a stream.)

c) Erosion/sediment control techniques must be incorporated into the construction-phase stormwater management plan. In order to be effective, these controls must be in place at the appropriate sequence in the construction operation.

During the post-construction phase Priority One areas were required (in the 1989 guidelines) to have:

a) buffer strips and setbacks as required in the construction phase.

b) a treatment or infiltration facility designed to treat or infiltrate a specified volume of stormwater from the developed area specified by Figure 1.

For Group A - Cold Water Fishery Areas of Priority One receiving waters, a discharge criteria for particle size was established. For this specified volume of runoff, the particle size in stormwater discharges was 40u or less. The volume criteria was based on the treatment or infiltration of approximately a 25 mm short duration (2-hour) rainfall (Figure 1).

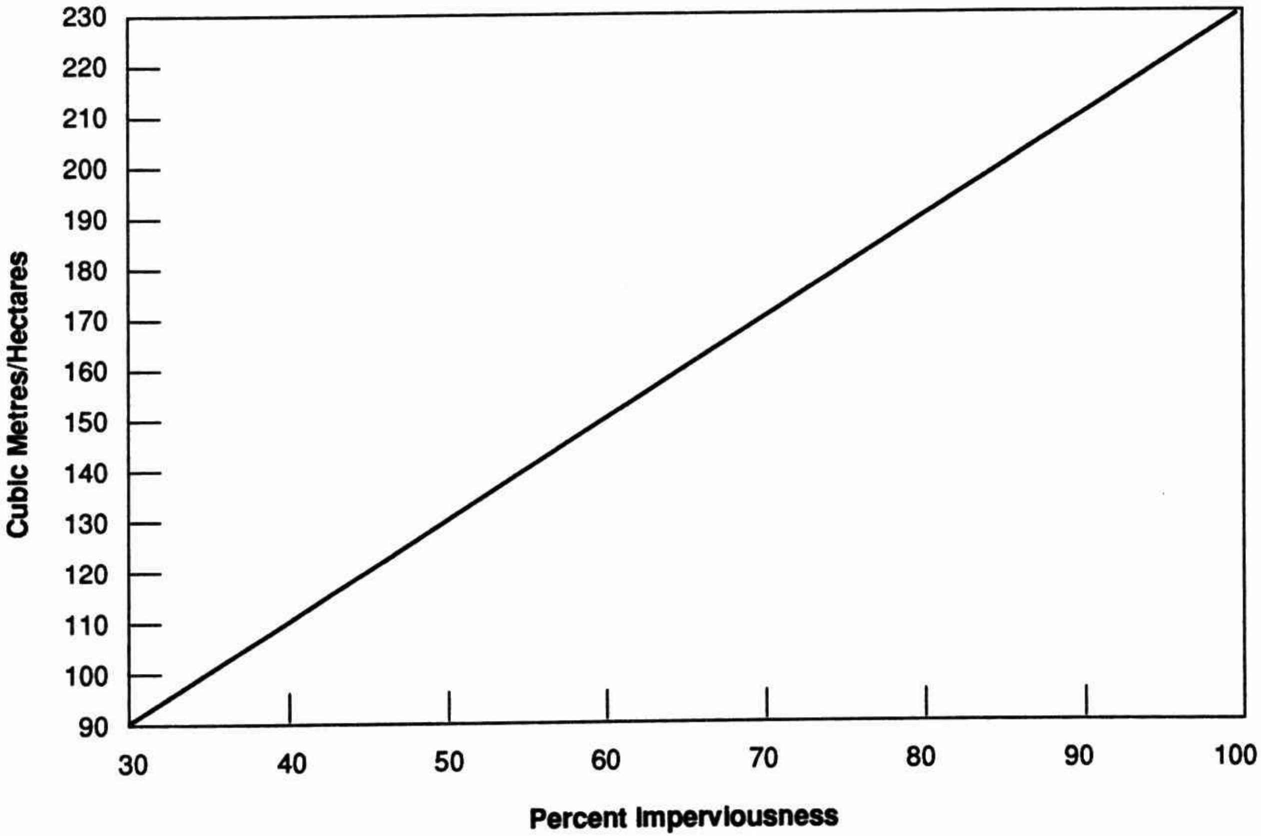

Figure 1: Stormwater Runoff Volume

For Group B - Body Contact Recreation Areas the fecal coliform density for this specified volume should not exceed 100 fecal coliform per 100 mL. Higher fecal coliform densities in stormwater discharges will be accepted if the discharge criteria are based on a receiving water assimilation assessment. The volume criteria was based on the treatment or infiltration of approximately a 25 mm, short duration (2-hour) rainfall.

[Editors' note. In June 1992 the Ministry of Health updated the recreational water quality criteria to 100 E. Coli per 100 mL.]

If the proposed development impacted both Group A and B waterbodies, then the guidelines for Group B had the additional requirement for removal of particle sizes of 40u or larger.

Techniques to control sediment or bacteria from new developments may include, but are not limited to stormwater detention ponds and infiltration facilities, the two control techniques shown to have a significant impact upon levels in storm water discharges. Other BMPs (e.g., see Schueler, 1989 and Chapter 8 in this volume) will also be considered, especially in terms of their ability to contribute to controlling or enhancing cold water fisheries or swimming objectives.

The 1989 guidelines also established that other on-site control techniques would be considered on a case-by-case basis and assessed on their ability to achieve the required degree of treatment. It was pointed out that promoting infiltration of stormwater on-site helps to reduce the total volume of runoff and hence the treatment capacity of the downstream control techniques.

Priority Two areas were defined as areas where stormwater from new urban development had the potential to impact waterbodies that support uses other than recreational body contact or existing/potential cold water fisheries. This included waterbodies that supported uses dependent on water quality such as, for example, a warm water fisheries. In certain instances where a specific warm water fishery were identified as being highly sensitive to stormwater impacts, these areas may be viewed as Priority One.

All new developments in Priority Two areas (except Consents) were required under the 1989 version of the guidelines to have the following items and control measures during the pre-construction and construction phase.

a) A construction-phase, stormwater management plan which addressed both water quantity and quality concerns.

b) Buffer strips and setbacks with a minimum of 15 horizontal metres of land from the receiving water must be retained with natural vegetation. Where no vegetation was present due to past poor land management practices, re-vegetation was required. This is consistent with the 1991 version of the guideline. Decreases in buffer strip width were permitted under the 1989 guidelines for certain conditions.

c) Erosion/sediment control techniques must be incorporated into the construction-phase stormwater management plan. In order to be effective, these controls should be in place at the appropriate sequence in the construction operation.

During the post-construction phase Priority Two areas were required under the 1989 guideline to have:

a) Buffer strips and setbacks as required in the construction phase.

b) Specific post-construction phase controls for stormwater, which may be required on a case-by-case basis depending on the specific uses of the receiving water.

2.5 Implementation of Proposed Guidelines

It was intended that the 1989 version of "Interim Stormwater Quality Control Guidelines" be implemented as a part of the land use planning process and that they be considered at all stages of the planning and development process. Implementation requires the co-operation of each developer, municipality, Conservation Authority and provincial agencies.

There are four planning tools identified in the 1989 document which supports stormwater management. They are:

a) Official and Secondary Plans and their Amendments

b) Plan of Subdivision

c) Zoning Bylaws

d) Site Plan Control

All of these planning tools are interrelated with the engineering works needed to affect stormwater management (Figure 2). As noted in the next paper in this volume, the suggested linkage is based upon integrating planning under the Planning Act with watershed planning mandated under the Conservation Authorities Act (see Chapter 16 of this volume).

Official and Secondary Plans should contain objectives and policies for stormwater quality control that (i) establish basic goals such as the protection of water quality and fish habitat; (ii) identify Priority One and Priority Two areas; and (iii) ensure comprehensive planning for stormwater quality control. The municipality should also include and develop the water quality component and fisheries component in the Master Drainage Plan, in addition to the traditional flood protection and erosion control components This would include the controls specified for Priority One and Priority Two Areas. In addition, the Master Drainage Plan should include the targets set out by the Watershed Plan (e.g., as were established in such places as the Don River Study or Rouge River Study).

A Plan of Subdivision must have all approval conditions placed on it by different agencies, cleared and approved by the Minister of Municipal Affairs or a delegated municipality before it can be registered and lots conveyed. Stormwater quality controls should be considered at the earliest possible stage since they may significantly affect such items as the subdivision lot layout. Controls could include such structural items as storm sewers, drainage courses and infiltration and pond facilities, and non-structural items such as provision for riparian vegetation.

Zoning By-Laws specify locations of permitted land uses within the municipality and specific development standards relating to those uses. Zoning by-laws can be used to identify specific setbacks for a lot, thereby providing for the protection of an area as a buffer.

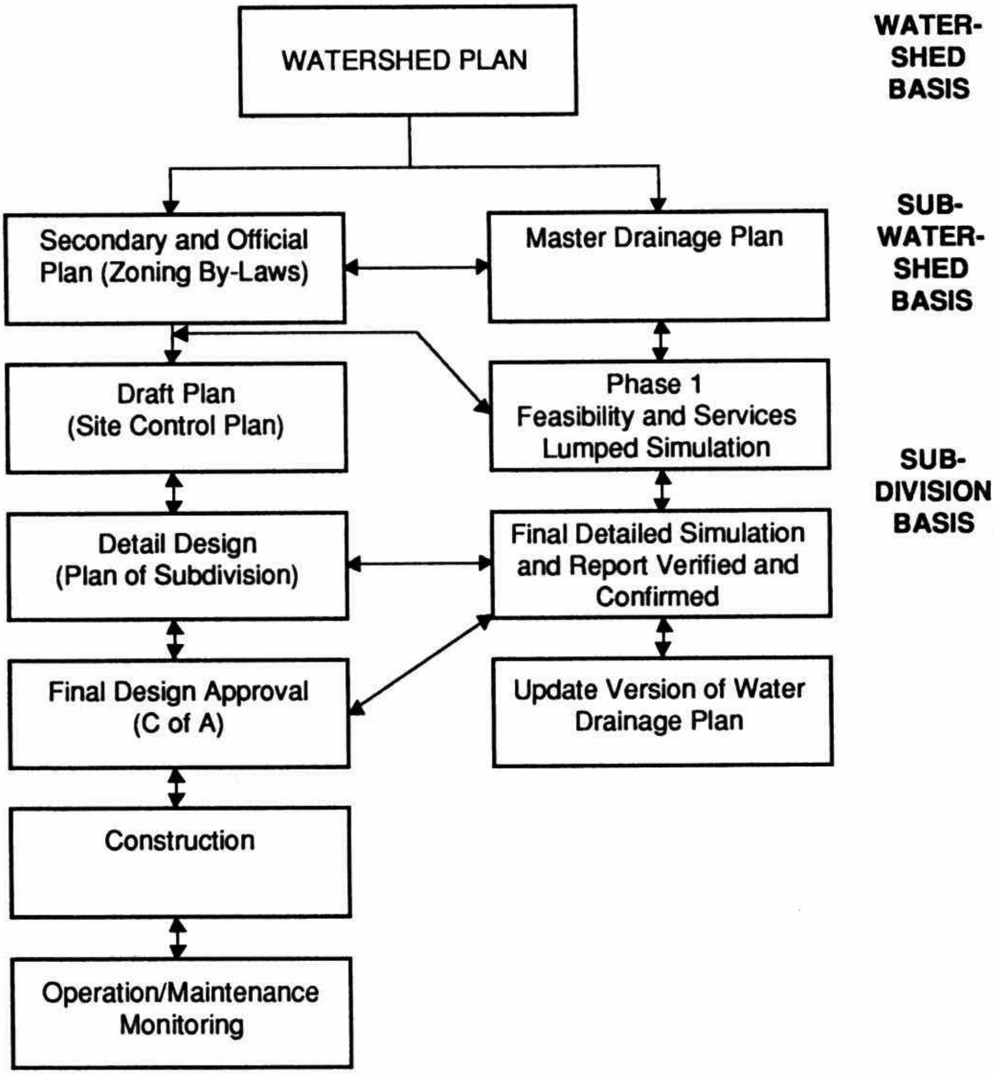

Figure 2: Stormwater Management Planning & Design Procedures

Site Plan Control is a planning tool that can be used to specify the stormwater quality control requirements for a specific development proposal. Site plan control is traditionally used to control grading or alteration of elevation or slope of land. Site plan control can be used to stipulate the location of on-site setbacks, buffer strips and vegetation cover. It controls grading or alternation of the elevation or slope of the land. It provides for the proper method of the disposal of stormwater, surface water runoff, and wastewater from the land.

2.6 Summary and Future Work

The management of stormwater must be considered using an integrated approach. The simple solution of constructing a stormwater treatment facility at the end of a subdivision is not a satisfactory approach. The approach must consider what we are trying to protect such as: "aquatic life and habitat, human health and safety and the ecosystem as a whole".

The "Interim (1989) Stormwater Quality Control Guidelines" attempted to achieve a part of the integrated approach. Based upon the need for integration, the philosophy adopted was that more than "stormwater quality management was required". Further emphasis must be placed on vegetative buffers for cooling of receiving waters, infiltration to ensure groundwater recharge and augment base flows in streams, and a public awareness of where stormwater goes and what can be done to protect it.

2.7 Acknowledgements

This paper was abstracted from the (draft) "Ministry of Environment and Ministry of Natural Resources Interim Stormwater Quality Control Guidelines". The Guidelines were developed by a writing team comprised of:

J. Beaver - MOE Central Region
P. White - MNR Central Region
E. Stanley - MOE Approvals Branch
M. Stirrup - MOE Water Resources Branch
D. Henry - MOE Water Resources Branch.

This document was in draft format in 1989 and was anticipated to be revised in March 1991. The document was entitled "Interim" in 1989 to ensure future revision as stormwater quality control technology and knowledge improve. The term "interim" is still applied to the guidelines in 1992.

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CHAPTER 3

Interim Stormwater Quality Control Guidelines
For New Urban Development (March 1991 Revision)

Anon (MOE/MNR Committee)

ABSTRACT

Interim guidelines for stormwater quality control are being used by provincial agencies to prevent/mitigate receiving water body impacts from new urban development. The document entitled "Interim Stormwater Quality Control Guidelines For New Development" describes the rationale, planning and implementation considerations, and water use guidelines. The most recent version (March, 1991) of the document has been reprinted here, with minor editing. A synopsis of a 1989 draft of the guidelines was presented in Chapter 2 above.

Individuals applying this document are advised to consult with the appropriate regional and/or district offices of both the Ministry of the Environment and the Ministry of Natural Resources and with the local conservation authority in the application of these guidelines.

If additional copies of the document are required please contact the Ontario Ministry of the Environment at (416) 323-4867.

3.1 Introduction

This document has been prepared jointly by the Ontario Ministries of Environment (MOE) and Natural Resources (MNR) to address stormwater quality requirements in developing areas of the Province. The management of stormwater encompasses flooding, erosion, fisheries, groundwater recharge, and water quality. Stormwater mandates of the two Ministries address the prevention of loss of life, minimization of community disruption and property damage due to erosion and flooding and the maintenance and enhancement of surface and ground water resources, sufficient for aquatic life, recreation and other uses.

CHAPTER 3

PLATE 1: GOAL OF GUIDELINES

The goal of the Interim Stormwater Quality Control Guidelines is the protection and enhancement of pre-development hydrologic and water quality regimes.

Specifically, the application of the guidelines will:

- provide municipalities with needed information for the preparation of planning documents and the review of planning proposals that ensure that stormwater management systems appropriately address water quality control.

- provide direction to development proponents for the preparation of master drainage and stormwater management plans for water quality control.

- provide guidance to MOE and MNR staff who evaluate and approve stormwater management facilities, stormwater management and master drainage plans for stormwater quality control.

3.2 The Need for Stormwater Quality Control

The proper control of drainage from urban areas is a concern of developers, municipalities, conservation authorities and provincial agencies. Existing practices and designs for servicing municipalities are intended to efficiently direct stormwater towards surface waters and transport it downstream. While affording desirable protection against the loss of both property and life, it is widely accepted that these practices degrade water quality and result in the reduction or loss of associated water uses (i.e., swimming, fishing and outdoor recreation etc.). Specific changes and impacts of urban development are summarized in Plate 2.

Continued intensification of urban growth and development in Ontario has aggravated water quality problems, both with respect to the number of water courses affected and the magnitude of the problem (i.e., degree to which water quality is impaired).

PLATE 2: CHANGES AND IMPACTS OF URBAN DEVELOPMENT

Changes

* *changes in landuse;*
* *changes in landuse activities;*
* *changes in drainage systems.*

Impacts of Development

* *increased density of drainage networks;*
* *increased surface runoff volumes and peak flows;*
* *higher surface flows;*
* *lower baseflows;*
* *increased frequency of more severe runoff events;*
* *increased pollutant loadings; and*
* *increased surface water temperatures.*

A dominant effect (editors' note) of urbanization is degradation of the quality of stream habitat due to alteration of the hydrological cycle. A few relevant considerations are given in Plate 3.

PLATE 3: URBAN RUNOFF QUANTITY CONSIDERATIONS CAUSED BY URBANIZATION

* *percent imperviousness of watershed is the most important factor in determining quantity of runoff.*

* *urbanization increases imperviousness of watershed.*

* *small frequent storms produce little if any runoff in natural catchments.*

CHAPTER 3

The Ontario Water Resources Act includes stormwater in its definition of "sewage". The Ontario Ministry of the Environment has the power under Section 24 of this act to review and approve stormwater treatment works. The historical evolution of non-point source control described in the Blue Book (MOE, 1984) is presented in Plate 4.

PLATE 4: HISTORICAL DEVELOPMENT OF MOE POLICY FOR NON-POINT SOURCES CONTROL

"Historically, control of urban point sources (i.e., municipal and industrial wastewaters) has received primary attention in water pollution abatement. However, there is growing concern over the significance and need for control of non-point sources of pollution (including atmospheric input of pollutants). Accordingly, in establishing effluent requirements for point sources, consideration must be given to the effects of contaminant inputs from non-point sources on receiving water quality. Conservation and remedial measures will be required for the control of non-point sources if they are shown to cause or contribute significantly to violations of the Provincial Water Quality Objectives."*

***Source:** MOE 1978 (revised 1984) Water Management Goals, Policies and Implementation Procedures ("The Blue Book").*

* *Stormwater is a non-point source pollutant.*

Ministry of Environment water quality abatement programs in the 60's, 70's and early 1980's focused on the impact of point sources of urban pollution, such as municipal and industrial wastewater treatment facilities. Abatement actions which followed these studies resulted in substantial water quality improvements, particularly for total phosphorus, bacteria and dissolved oxygen. From more recent studies, an appreciation of the importance of non-point sources of pollution was gained, especially the role of stormwater and its cumulative impact. These studies (Toronto Area Watershed Management Study, Rideau River Basin Study, Metro Toronto Remedial Action Plan, North Bay and St.

Catharines Pollution Control Plans) demonstrated that contaminated stormwater was a major contributor to the degradation of water quality, restriction of water uses and the destruction of fish stocks and aquatic habitats.

Urban stormwater runoff carries a wide range of pollutants. The variability of the composition of stormwaters, the sources of these contaminants and resultant loading estimations are recognized in the presentation of average pollutant concentrations in Table 1. Marsalek and Ng (1989) suggest that the variations in stormwater pollutant concentrations should be considered in the context of intended use of such data, e.g., comparison of relative contributions of pollutant sources and the development of cost effective remedial measures.

Parameter selection for Table 1 was based on commonly monitored parameters known to be significant contributors to water quality problems. Organics and pesticides etc. are not shown due to the inherent variability and little data.

The above named studies also demonstrated that the *remediation* of urban water quality and water uses may be extremely expensive, and achievable only over long periods of time. Even then, there are certain restrictions or limitations with respect to clean-up of these waterbodies and the restoration of desired water uses.

When an urban waterbody is polluted, certain water uses are either lost or restricted. For example residents may be unable to swim, fish, boat or to enjoy more passive recreational activities such as hiking or picnicking. A second less tangible constraint is the loss or reduction in intrinsic benefits associated with a clean waterbody. An example is public expectation and insistence that surface waters are clean and safe to use. A related consideration is the cost or inconvenience of providing, or meeting desired water uses at alternate locales. For example the expense and time required to travel to outside areas (natural uses), the provision of swimming pools, water fountains, ponds and water amusement parks or the disinfection of beaches.

Stormwater should be viewed in the context of a resource to be managed and used in support of societal benefits, as opposed to the traditional approach - a waste to be drained and disposed of as quickly as possible. Beneficial uses of stormwater include: aesthetic landscaping, lawn and garden watering, washing and fire protection. Through infiltration processes, stormwater also has an important role in the maintenance of base flows, cool summer water temperatures and groundwater recharge.

CHAPTER 3

TABLE 1: URBAN STORMWATER POLLUTANT CONCENTRATIONS

Parameter	U.S. EPA	East York	St. Catharines	Kingston	Provincial Water Quality Guidelines
Total Suspended Solids (mg/L)	125	281	250	72	
Biological Oxygen Demand (mg/L)	12	14	8.2	8.5	
Chemical Oxygen Demand (mg/L)	80	138	--	--	
Total Phosphorus (mg/L)	0.41	0.48	0.33	--	0.0
Soluble Phosphorus (mg/L)	0.15	0.06	0.084	0.118	
Total Kjeldahl Nitrogen (mg/L)	2.00	2.20	0.89	--	
Nitrate and Nitrite (mg/L)	0.90	0.46	0.65	0.25	
Total Copper (mg/L)	0.040	0.050	0.021	0.009	
Total Lead (mg/L)	0.165	0.570	0.084	0.013	
Total Zinc (mg/L)	0.210	0.330	0.100	0.064	
Fecal Coliform	21,000	11,000	68,000	21,000	

U.S. EPA - Mean concentration for median urban site
Nationwide Urban Runoff Program (NURB) (Driscoll and Mangarella, 1990)

- Fecal coliform, Median Event Mean Concentration (EMC), 11 sites
NURP (U.S. EPA, 1983)

East York - Arithmetic mean, 18 events, 1 site (Kronis, 1982)
St. Catharines - Geometric mean, 4 events, 1 site (SCAPCP, 1990)
Kingston - Geometric mean, 8 events, 1 site (CH2M Hill, 1990)

3.3 Planning and Implementation Considerations

As a first step the Interim Stormwater Quality Control Guidelines are intended to assist with the planning, design and implementation of stormwater works. In addition, the guidelines are written to promote research and to encourage the demonstration and application of technically sound and innovative solutions.

Stormwater quality management requires sound planning and technical evaluation to assist implementation of these guidelines. The relative roles of Land Use Planning and technical assistance are summarized in Plate 5.

PLATE 5: IMPLEMENTATION CONSIDERATIONS

- *Stormwater quality control should be coordinated with land use planning and considered at all stages of the planning and development process.*

- *MOE and MNR to provide technical assistance to municipalities and developers in the preparation of planning documents and development applications.*

The Interim Stormwater Quality Control Guidelines are a part of a developing provincial strategy for management of urban watersheds being formulated jointly by MOE/MNR. Interim Stormwater Quality Control Guidelines are to be considered in conjunction with Watershed Management, Master Drainage and Stormwater Management Plans, and Municipal Planning documents whose roles are outlined in Figures 1 and 2.

Stormwater quality control should be co-ordinated throughout the land use plan review process and considered at all stages of planning and development. A high degree of co-operation and understanding will be necessary on the part of the developer, municipality, conservation authority and provincial agencies. A lack of co-operation can lead to, and in the past, has resulted in costly and complex pollution and drainage problems, and delays in the development approval process.

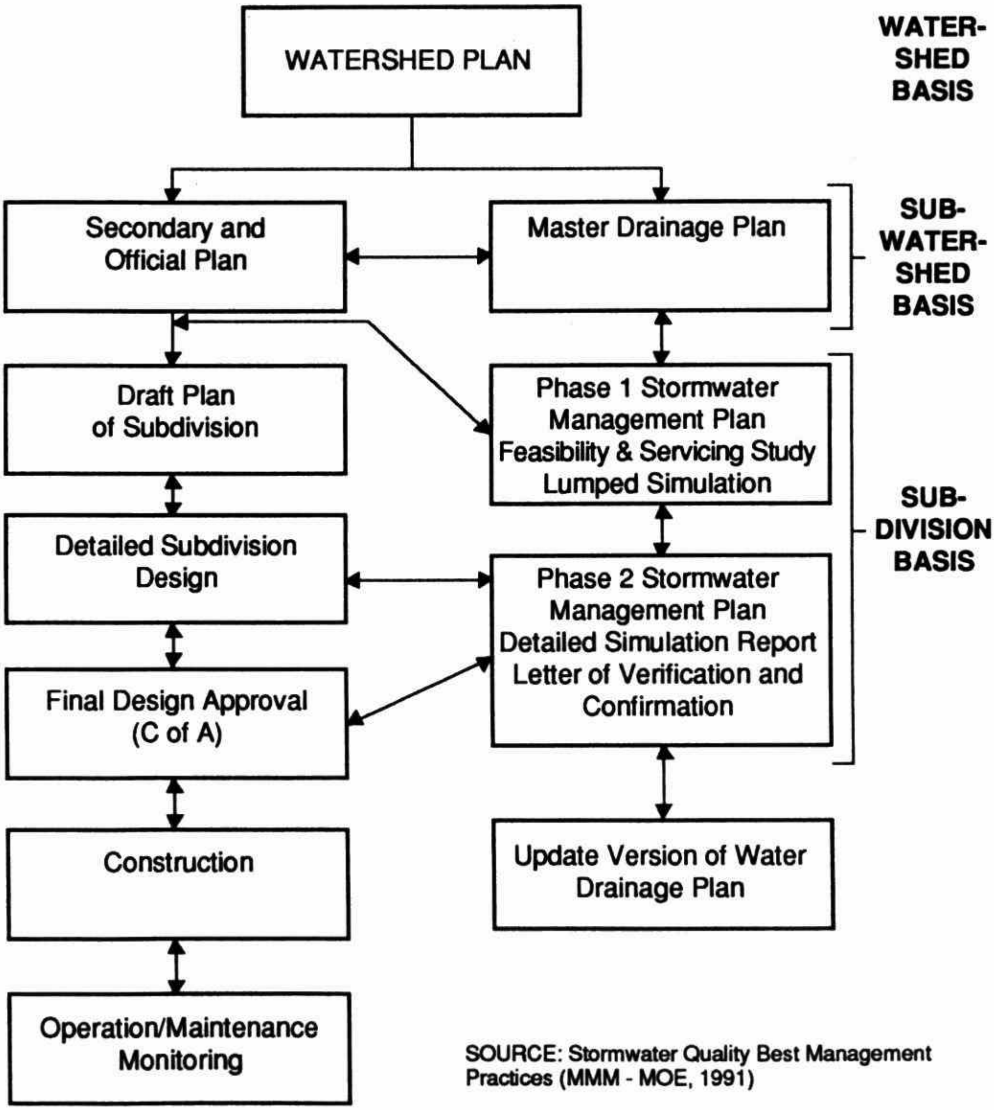
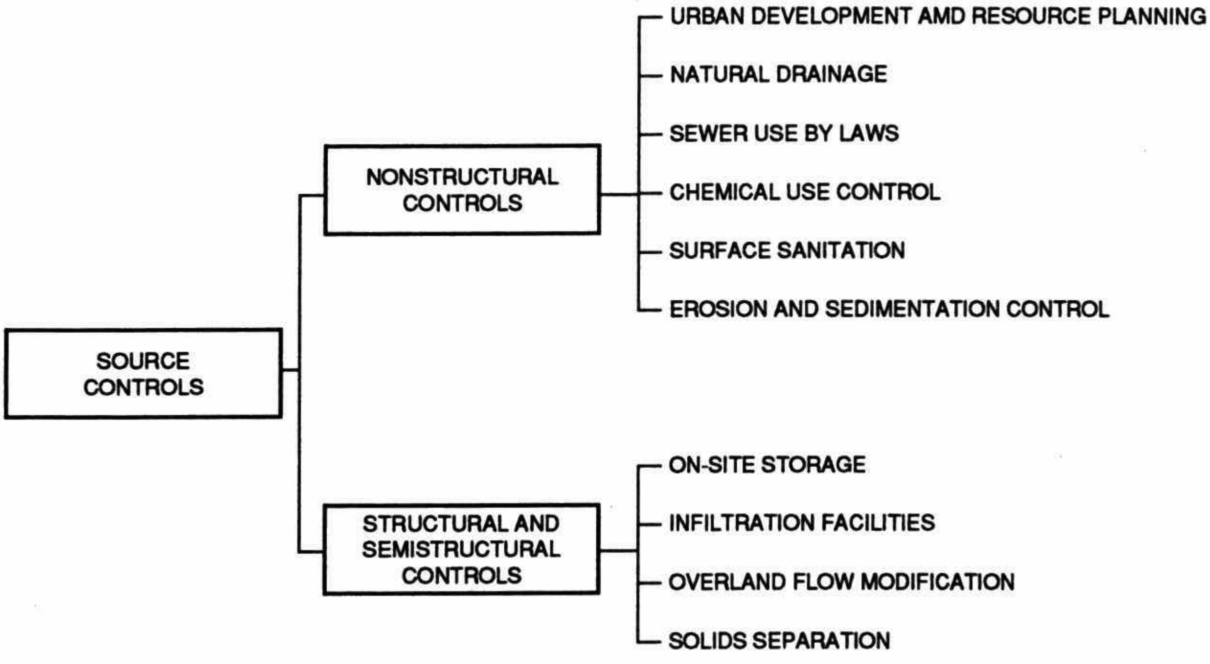


Figure 1: An Integrated Approach for Watershed Management, Land Use Planning and Stormwater Management



(Modified from Marsalek, 1990)

Figure 2: Urban Stormwater Management Source Controls

CHAPTER 3

Official plans set out objectives and policies which the municipalities use to guide development. It is recommended that municipalities make a commitment in their official and secondary plans to protect or enhance the water uses identified in the Watershed Management Plan. In addition municipalities should undertake comprehensive planning for stormwater quality control and that this planning should be an early element of landuse planning.

Watershed Management Plans will define existing and potential uses for specific segments of the watercourse and will identify supporting requirements, e.g., hydrology, biology, groundwater and stream morphology components. Master Drainage Plans address requirements for stormwater quality and quantity management at the sub-watershed scale.

In areas lacking Watershed Management Plans, municipalities and proponents of new development will be required to determine existing and potential water uses and any requirements for the protection of the environment.

Secondary Plans provide detailed land use plans and policies for a portion of the area covered by the Official Plan. If a secondary plan is to be prepared it should be done concurrently with a Master Drainage Plan. The Master Drainage Plan would include water quality requirements as set out in this document and by other agencies.

Stormwater quality controls should be considered at an early stage in the subdivision planning process (Plan of Subdivision) since these controls will significantly affect the layout of lots in a subdivision. Subdivision planning should not be undertaken independently, nor should each subdivision necessarily have its own stormwater quality control facilities.

Stormwater Management Plans prepared by the developer should be based on the requirements of the Watershed Management Plans, Master Drainage Plans, Official and Secondary Plans. These plans should indicate the impact of the proposed development on water quantity and quality, discuss any proposed mitigation measures to overcome drainage problems and ensure integration with the Master Drainage Plan.

3.4 Guidelines for Water Use Protection

3.4.1 Philosophical, Technical and Implementation Considerations

In developing these guidelines, the two ministries have taken steps to provide directions for the integration of quantity and quality in the management of stormwater and to incorporate guidance for the protection of base flows and groundwater supplies.

It is also the intention of the guidelines that stormwater planning conform to or consider broader based objectives, such as ecosystem management, sustainable development and no net loss of fisheries or fish habitat.

In new developing areas proponents will be required to indicate the effects of their development, to look for opportunities to improve and to provide acceptable mitigative measures to ensure that surface waters are of a quality which is satisfactory for aquatic life and recreation.

The development of the guidelines for the water quality control of stormwater was based on four principal considerations:

- That initial storm runoff is typically high in pollutants accumulated during antecedent dry periods.
- That source controls must be employed to minimize the contamination of storm runoff at the source.
- That it is essential to reduce the volume of storm runoff moving off site.
- That the control of storm runoff is to be approached from a volume, frequency and duration perspective.

Concepts for designing the route of stormwater runoff to achieve these considerations are given in Plate 6.

PLATE 6: CONCEPTS FOR PLANNING AND DESIGN OF STORMWATER RUNOFF SYSTEMS

Urban drainage planning and designs should adopt the following concepts:

* *site drainage to the receiving watercourse should maximize the use of overland flow networks through the use of grassed swales, natural channels, infiltration trenches and basins, and wetlands.*

* *natural drainage/overland flow of stormwater runoff should be integrated with open space and park dedication.*

* *planning and design of stormwater runoff systems must take place at early stage of the development/construction process in order to capitalize on regional opportunities.*

Source controls for the control of stormwater from industrial and residential sites include: on-site reduction of pollutants, indirect site drainage (i.e., lot grading, grass swales or wetlands, natural channel designs and techniques which maximize infiltration), spill controls and the elimination of direct roof connections to storm sewers. Figure 2 explains differences between structural and nonstructural source controls. Whenever possible, drainage designs for stormwater should maximize the use of surface drainage as opposed to sewer systems. Hydrogeology studies will be required to establish the appropriateness of stormwater infiltration techniques. On the basis of groundwater sensitivities, these studies will define areas for infiltration and volume(s) of stormwater which can be infiltrated.

The directives for stormwater quality management presented in this section concentrate on the control of suspended solids and bacteria. Since many pollutants present in

stormwater are directly associated with suspended solids, the control of nutrients, trace metals and organics may, to a certain extent, be realized in terms of reduced suspended sediments.

Stormwater control design guidelines and the suggested approach for the integration of quality and quantity in the control of stormwater can be implemented within legislative, policy and administrative procedures already in place. Stormwater management schemes which integrate source controls, offline storage and treatment are recommended, and may prove to be both cost-effective and successful.

The Interim Stormwater Quality Guidelines are intended to encourage proponents of new developments to investigate and apply technically sound and innovative approaches in their management of stormwater. This document is entitled "Interim" to reflect the intention that the guideline will be reviewed periodically by the two ministries and updated as new water quality assessments and management technologies for stormwater are developed and evaluated.

In addition to MOE/MNR efforts in the development of stormwater management guidelines and design manuals, conservation authorities, developers and their consultants are encouraged to continue their own research and to bring forward innovative approaches for the management of stormwater.

3.4.2 Technical Literature Available to Assist Implementation

The preceding sections introduced underlying philosophical, technical and implementation considerations for the quality control of stormwater. This section expands on the "how to" aspects of controlling stormwater from a quality perspective.

Technologies for the infiltration of stormwater and the reduction of pollutants on site, are available and are being evaluated by MOE and MNR. Once these evaluations are completed, design and operation manuals will be distributed. In the intervening period technical reports, scientific literature and conference proceedings are available for consultation.

Other technical literature and relevant guidelines are summarized in Plate 7.

PLATE 7: RELATED DOCUMENTS FOR UNDERSTANDING AND CONTROLLING STORMWATER QUALITY

* *Guidelines on Erosion and Sediment Control for Urban Construction Sites.*
* *Urban Drainage Design Guidelines.*
* *Model Sewer Use By-Law.*
* *Guidelines on the Design and Development of Instream Works.*
* *Fisheries Management Plans.*
* *Guidelines on Design and Development of Buffer Strips Along Lakes and Streams.*
* *Guidelines on Design and Development of Utility Corridor Crossing of Streams.*
* *MTO Drainage Policy and Practices Guidelines.*
* *Design and Construction Guidelines -Drainage Act.*
* *Class Environmental Assessment Documents.*
* *Provincial Policy Statements on Wetlands.*

3.4.3 Overview of the Guidelines

Guidelines for stormwater quality control are presented in Table 2 and include requirements for buffer zones and setbacks, volume control, and water use protection. At present, the guidelines for controlling stormwater are based upon best professional judgment, with respect to practicality and performance.

There will be certain sensitive areas in the Province where development may not be feasible regardless of the level/extent of stormwater management.

Stormwater quality control guidelines are provided for the protection of coldwater and warmwater fisheries and selective water uses (e.g., recreation and aesthetic uses). MNR District Fisheries Management Plans classify Ontario's waterbodies (lakes, streams) as either cold or warm water habitats. This classification is based on summer water temperatures and resident fish communities. Coldwater streams and lakes contain fish communities consisting of a mixture of salmonids (trout, salmon) and warm water tolerant species (small mouth bass, sunfish, bullheads). Warmwater fish communities do not include resident salmonids.

Coldwater fish communities have stringent (i.e., sensitive) habitat requirements - thus the rationale for stringent stormwater quality controls to protect these streams/lakes. The less stringent controls advocated for warm water streams are deemed adequate to maintain/ enhance these fishery. More stringent controls may be required for significant or sensitive warm-water fisheries on a case-by-case basis.

Water use protection guidelines identified in Table 2 are *in addition* to the stormwater quality control guidelines for fishery protection. As the need arises, additional water use protection guidelines for control of stormwater will be established by MNR/MOE.

Water uses are to be defined in Watershed Management Plans prepared by local Conservation Authorities with input from Ministry of Natural Resources and Environment Ontario. Where Watershed Management Plans have not been prepared, proponents of new development and municipalities will be required to provide an assessment of the waterbody and to meet with Conservation Authorities, MNR and MOE to determine existing/potential water uses and any requirements for the protection and enhancement of these resources.

TABLE 2: STORMWATER QUALITY CONTROL GUIDELINES AND WATER USE PROTECTION

STORMWATER QUALITY CONTROL GUIDELINES

Sensitivity (fisheries)	Buffer Zones (streams/lakes)	Volume Controls	Sediment Controls
Coldwater fisheries (sensitive)	30 m	25 mm	in place during all phases of development and construction
Warmwater fisheries (less sensitive)	15 m	13 mm	in place during all phases of development and construction

In addition, the following Water Use Protection Guidelines may be required:

Recreation (swimming): Other than for four discharge occurrences (extreme events) meet 100 E. Coli per 100 mL swimming objective (see Section 3.8).

Aesthetics: Stormwater be devoid of debris, oil, scum and substances which produce objectionable odour, colour, deposits, or excessive turbidity.

<u>Other Uses</u>

Drinking Water, Irrigation, Agricultural, etc.: Directives will be established in consultation with Conservation Authorities, MNR and MOE as the need arises.

3.5 Instream Habitat Protection: Buffer Zones and Setbacks

3.5.1 Guidelines for Buffer Zones

Vegetated buffer zones provide several amenities and water quality benefits. A few of these are summarized in Plate 8.

PLATE 8: ADVANTAGES OF VEGETATIVE BUFFER ZONES

* *act as sediment and nutrient filters.*
* *prevent streambank erosion.*
* *provide temperature control.*
* *provide food sources.*
* *enhance aesthetics and recreation.*
* *physical barrier to human/ development activities.*

In accordance with established MNR requirements a minimum of either 15 or 30 horizontal metres of land from a waterbody must be retained with natural vegetation during all phases of development. Buffer zone widths as specified in Table 2 vary according to the type of fishery sustained by the stream. Where no vegetation exists within the buffer zone, due to poor land management, revegetation will be required. To ensure that buffer zones are not damaged during the construction phase, they must be clearly marked and protected. More stringent buffer requirements may be necessary for stream corridors with sensitive soil conditions (i.e., high permeability, shallow depths or extensive organic soils) in order to maintain integrity of the watercourse.

3.5.2 Implementation of Setbacks and Buffer Zones

Zoning bylaws can be used to identify specific setbacks for lots, thereby providing for the protection of an area adjacent to buffers. To be effective, stormwater management techniques such as buffer zones and setbacks must be required and enforced by the municipality through zoning bylaws.

Site plan controls adopted in official plans can be used effectively to:

1. specify the location and maintenance of buffers and type of vegetation cover;

2. control alteration to elevation or contour of the land;

3. specify the location of buildings, fences or structures requiring on-site setbacks.

3.6 First Step in Stormwater Quality Control: Volume Control

Source controls which reduce the amount of impervious area or restrict the discharge of stormwater to sewers should be used first to achieve specified volume controls. Vegetative and structural best management practices which enhance infiltration are gaining agency and public acceptance. Stormwater quality ponds should be considered as the last line of defense and applied only after all opportunities for infiltration of stormwater have been exhausted.

Volume control guidelines are to be applied as runoff control limits for a 13 or 25 mm short duration (2 hr) rainfall. These controls are to be applied in the following order:

1. at source (on-site) infiltration techniques if soil characteristics and groundwater conditions are suitable;

2. grading that uses natural and/or man-made surface drainage routes to maximize infiltration if soil characteristics and groundwater conditions are suitable;

3. structurally controlled infiltration techniques if soil characteristics and groundwater conditions are suitable;

4. wet ponds;

5. extended detention ponds.

Factors affecting the suitability of "at source" (on-site) techniques for volume control are presented in Plate 9.

3.7 Stormwater Quality Control of Suspended Solids: Sediment Controls

Sediment and erosion may increase by one thousand fold (or more) during construction phases of new development. Associated with eroded sediments are a variety of nutrients, trace metals and organic pollutants. To be effective, sediment control must be in place throughout all phases of the development and construction process, especially during phases when the site is unvegetated (editor's note).

PLATE 9: FACTORS AFFECTING SUITABILITY OF SOURCE CONTROLS FOR VOLUME MANAGEMENT

* *soil permeability;*
* *drainage area served;*
* *local acceptance;*
* *slope;*
* *space restrictions;*
* *land use restrictions;*
* *land use type;*
* *hydrogeologic conditions;*
* *aquifer use.*

Techniques for erosion and sediment control are provided in the UDIC 1987 report entitled "Guidelines on Erosion and Sediment Control for Urban Construction Sites". The 40 microns guideline for sediment control (given in Table 2) is based on best professional judgement with respect to particle settling control design and performance. Performance is considered in terms of the ability to protect fish habitats, and to improve recreational opportunities.

(Editors' note. The ability of sediment control techniques to remove the 40 micron particles requires monitoring data to prove the effectiveness of the techniques. Practitioners are encouraged to obtain performance data to improve stormwater quality management.)

3.8 Water Use Protection Guidelines for Recreational Uses of Receiving Waters

Water use protection guidelines of 100 E. Coli per 100 mL sample are identified in Table 2 for the protection of downstream beaches. [Editor's note. In June 1992, the Ministry of Health updated the recreational water quality criteria from 100 fecal coliform per 100 mL to 100 E. Coli per 100 mL.]

Traditionally, stormwater quality ponds are used to treat stormwater for both bacteria and suspended sediments. Pond studies for the Rideau River Stormwater Management Study (1983) suggest that a settling time of 12 to 24 hours may be required to achieve 90% removal efficiency of suspended solids (see Table 3). In addition, 72-96 hours retention may be required to achieve the bacterial water use protection guidelines.

[Editors' note. The detention time of the pond is a key variable for defining pond performance. In addition, the method of operating the pond (batch; continuous inflow/outflow), the mean depth, the geomorphological characteristics of erosional and depositional regimes, and the nutrient content (which can lead to bacterial multiplication) must be considered. In view of these complexities, the application of an active treatment technology in the form of ultraviolet irradiation is being evaluated in recent studies, since a passive settling technology of a pond appears inadequate to achieve the effluent objectives of 100 E. Coli/100 mL. Some of the considerations in developing this technology are given in Chapter 11 of this volume by Brierley *et al.*]

3.9 Development of a Best Management Practices Plan

[Editors' note.] The terminology "Best Management Practices" have evolved from being housekeeping and spills prevention (pollution prevention) techniques to include structural devices and BMP trains where a physical facility is provided at the downstream end of several stormwater conveyance systems. The BMP trains are used to control the release rate of water, and to use passive engineered systems (gravity-settling; bacterial decay; chemical hydrolysis) to remove pollutants. An overview of the use of BMPs for water quality protection is provided in Plate 10.

Detailed aspects for selecting BMPs and design BMPs are given in several of the references listed in Section 3.11, including Schueler (1987) and MMM (1991). An overview of the specific limitations of dry ponds and wet ponds for achieving stormwater quality control is given in Plate 11.

TABLE 3: AVERAGE CONCENTRATION REMOVAL RATES FOR EXISTING MONITORED RETENTION PONDS IN ONTARIO

Retention Pond	SS	P	N	BOD	Zn	Pb	Fecal
Uplands	79	45					93
Borden Farm	59	48					69
East Barrhaven	52	47					56
Merivale	83	46					87
Hunt Club Ridge	90	63					
Kennedy Burnett (batch)**	98	79	54	36	21	39	99
Kennedy Burnett (cont.)**	93	86	57	57			85
Lake Aquitaine	65	77	47				
Lake Wabukayne	0	25	0				
Mill Pond*	54	79					

Results are averages for all monitored storms

* Results are for the combination of wet pond and natural wetland

** Mass loading results

Source: Stormwater Quality Best Management Practices (MMM - MOE, 1991)

PLATE 10: BEST MANAGEMENT PRACTICES

'Best Management Practices' (BMPs) has gained wide acceptance as a general term designating procedures for quality and quantity control of stormwater.

Techniques considered to be BMPs:

* *reduce pollutants available for transport by runoff.*
* *reduce amounts of pollutants in runoff before it is discharged.*

BMPs are used to reduce pollutants to:

* *alleviate or mitigate existing water quality concerns; and,*
* *to avoid future problems, where none exist.*

3.10 Monitoring and Auditing of the Environmental Response to Stormwater Quality Control

Continuing work will be required to ascertain the response of the environment to these stormwater quality control guidelines and to evaluate control performance. Ideally these activities would entail more than straight water quantity/quality sampling. Emphasis should be placed on the qualitative assessment of guideline performance through field inspection on both developed lands and the receiving streams. Findings from these reviews should be incorporated in updates to appropriate regulations/ bylaws, guidelines, design manuals and implementation strategies.

Key components of environmental response reviews would be the inter-agency transfer of information and education, training and public consultation. Information gathered by this program will be used to guide enforcement and research in the developing field of urban stormwater quality management.

PLATE 11: STORMWATER QUALITY PONDS

Stormwater quality ponds reduce pollutant concentrations through sedimentation and biological processes.

DRY PONDS:

* *flood and erosion control;*
* *limited and ineffective water quality enhancement;*
* *old thinking;*
* *can be retrofitted for water quality control.*

WET PONDS:

* *permanent pool of water;*
* *may provide high removal of suspended particulates;*
* *reduction in nutrients, trace metals and bacteria.*

EXTENDED DETENTION PONDS:

* *modifications to dry ponds to detain water;*
* *ponds to drain in 24 to 48 hours;*
* *minimum storage at other times;*
* *dual role for quantity and quality control.*

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CHAPTER 3

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CHAPTER 4

Stormwater Regulations and CSO Strategy in the U.S.A.

Harry M. (Hap) Thron

ABSTRACT

This paper reviews the strategy being used by the United States Environmental Protection Agency to regulate CSOs and stormwater discharges in the U.S. using the National Pollutant Discharge Elimination System (NPDES) permit system.

The strategy for CSOs required each state to develop and submit to the EPA a permitting strategy (identify CSOs; establish priority for permit issuance). The specific strategy for each city will vary due to the complexity of the problem, technical and cost considerations, but will generally involve registration, monitoring, and a plan to control CSOs. The U.S. Federal Government will use its power to advocate control, but plans no direct federal funding other than to develop technical guidance documents. EPA has formulated minimum technology-based limitations and may require additional CSO control measures on a case-by-case basis to meet technology-based and applicable state water quality standards.

The approach for urban stormwater involves three tasks. Stormwater discharges were first identified, which should be designated for immediate permitting. The second task was to establish permit application requirements for classes of stormwater discharges of high priority (industrial discharges direct to receiving waters and municipal discharges in cities over 100,000); this is complete. The third task, to study and report to Congress the nature and extent of the problem from other sources including small cities, and control methods, is expected to be completed in 1992.

CHAPTER 4

4.1 Introduction

The control of stormwater by the permit process has had a lengthy and somewhat confusing history. The United States Environmental Protection Agency (U.S. EPA) is currently using the NPDES permit program for storm water discharges and combined sewer overflows. The NPDES permit system was established under the Clean Water Act (CWA) to identify sources of pollutant discharges and to assist in their regulation and control.

This paper focuses on the regulation of stormwater by providing some background on the scope of the problem and describes the stormwater permit initiative and the national control strategy on combined sewer overflows.

4.2 Historical Causes of Water Quality Degradation

The Clean Water Act prohibits the discharge of any pollutant to navigable waters from a point source unless the discharge is authorized by an NPDES permit. Efforts to improve water quality under the NPDES program have traditionally focused primarily on reducing pollutants in discharges of industrial process wastewater and municipal sewage. This program emphasis has developed for a number of reasons. At the onset of the program in 1972, many sources of industrial process wastewater and municipal sewage were easily identified as responsible for poor, often drastically degraded water quality conditions. However, as pollution control measures were developed for these discharges, it became evident that more diffuse sources of water pollution, such as agricultural and urban runoff were also major causes of water quality problems. Yet some of these same sources, agricultural runoff and irrigation return flows, are statutorily exempt from the NPDES program.

Although assessments of water quality are often extremely difficult to perform, several national assessments of water quality have been made and helped to define the extent of the problem. For the purpose of these assessments, urban runoff is considered to be diffuse or nonpoint source pollution, although legally, most urban runoff is discharged through systems such as separate storm sewers or other conveyances which are point sources under the CWA, and are subject to the NPDES program. The "National Water Quality Inventory, 1986 Report to Congress" provides a general assessment of water

quality based on biennial reports submitted by the States as required by Section 305(b) of the CWA.

In preparing these Section 305(b) Reports, the States were asked to indicate the fraction of the States' waters that were fully supporting, partly supporting, or not supporting designated uses. The reports indicated that of the rivers, lakes, and estuaries that were assessed by States, roughly 75% are supporting the uses for which they are designated. For waters with use impairments, States were asked to determine impacts due to nonpoint (agricultural and urban runoff and other sources,), municipal sewage, industrial (process wastewaters), combined sewer overflows, natural, and other sources. Based on 37 States that provided information on sources of pollution, industrial process wastewaters were cited as the cause of nonsupport for 9% of the rivers and streams, 1% lakes, and 8% estuaries. Municipal sewage was the cause of nonsupport for 17% rivers and streams, 8% lakes and 22% estuaries. Nonpoint sources were the cause of nonsupport for 65% of rivers and streams, 76% lakes and 45% estuaries. The Assessment concluded that pollution from diffuse sources such as runoff from agricultural and urban areas is the leading cause of water quality impairment. These sources appear to be increasingly important contributors to use impairment as discharges of process wastewaters from industry and municipal sewage plants come increasingly under control.

4.3 Nationwide Urban Runoff Program (NURP)

From 1978 through 1983, EPA provided funding and guidance to the Nationwide Urban Runoff Program (NURP). The NURP program included 28 projects across the U.S., conducted separately at the local level but centrally reviewed, coordinated, and managed. One focus of the NURP program was to characterize the water quality of discharges from separate storm sewers which drain residential, commercial, and light industrial sites. The majority of samples collected in the study were analyzed for eight conventional pollutants and three metals. Data collected in NURP indicated that on an annual loading basis, suspended solids in discharges from separate storm sewers draining residential, commercial and light industrial areas can be greater than suspended solids in effluent from sewage treatment plants receiving secondary treatment.

A portion of the NURP program also involved monitoring 120 priority pollutants in storm water discharges. Seventy-seven priority pollutants were detected in samples of storm

water discharges from residential, commercial and light industrial lands taken during the NURP study, including 14 inorganic and 63 organic pollutants.

Numerous priority pollutants were detected in at least ten percent of the NURP samples analyzed for priority pollutants. These included lead (94%), zinc (94%), copper (91%) chromium (58%), arsenic (52%), pesticides (endosulfan, chlordane and lindane, 15-19%), pentachlorophenol (19%), phthalates (22%), and fluoranthene (16%). The NURP data also showed a significant number of these samples exceeded various freshwater quality criteria.

Thus, it is apparent that storm water runoff is a potentially significant source of pollution that must be dealt with. The NPDES permit is an appropriate vehicle to address the problem, inasmuch as it is well-suited to both <u>quantitative</u> controls in the form of effluent limits on selected pollutants and <u>qualitative</u> controls such as best management practices in special conditions.

4.4 Control of Storm Sewer Discharges

The approach for controlling storm water through the permit program and, specifically, the control of discharges from municipal separate storm sewers and industry is defined in the Water Quality Act of 1987. This act defined EPA's regulatory strategy for storm water by prescribing a <u>phased</u> and <u>tiered</u> approach. The Act "phases in" permit <u>application</u> requirements and deadlines, permit <u>issuance</u> deadlines and permit <u>compliance</u> deadlines for different categories of storm water discharges. The Act prescribes different <u>tiers</u> of control for industrial discharges of storm water versus discharges from municipal separate storm sewers. Discharges associated with industrial activity are controlled utilizing the best available technology (BAT) whereas permits for municipal separate storm sewers must require that the discharge be controlled to the maximum extent practicable (MEP) and must include a requirement to effectively prohibit non-storm water discharges to the storm sewer.

The first task for EPA resulting from this act, was to identify storm water discharges which should be designated for immediate permitting because they contribute to a violation of a State water quality standard or are significant contributors of pollutants to waters of the U.S. To date, few such sources have been so designated, perhaps because

they are already controlled adequately by current permits. It is also plausible that the Regions and States are awaiting more definitive guidance in the form of the final permit application regulations before proceeding.

The second task for EPA was to establish permit application requirements for classes for storm water discharges identified as high priority. These include discharges associated with industrial activity and discharges from municipal separate storm sewer systems serving populations of 100,000 or more. There are approximately 170 cities with such systems in the U.S. The EPA published a proposed rule prescribing application requirements for industries and cities on December 7, 1988 and received 450 sets of comments on the proposed rule. Many comments addressed the definition of municipal storm sewer system, illicit discharges, industrial group applications, industrial indirect discharges to municipal separate storm sewer systems, the cost of municipal permit applications and sampling procedures. The EPA plans to carefully consider the comments and then to make recommendations to the Administrator on the form of the final rule. [See Editors' note at conclusion of this paper.]

The third task is the requirement for EPA to conduct studies and report to Congress on the nature and extent of the storm water problem for the smaller cities and the non-industrial or commercial discharges, as well as industrial discharges to separate storm sewers in the smaller cities, the so-called moratorium sources. EPA has drafted the first storm water report on the "nature and extent" of the storm water problem and has sent it to the internal Agency workgroup for review. It went to Congress in 1990. Some of the preliminary findings of the study include the following:

- Discharges from municipal separate storm sewer systems are a major source of pollutants to receiving waters in urbanized areas.

- Nine major classes of non-municipal storm water dischargers are associated with a high potential for pollutants in storm water including:

    - mining and oil and gas production facilities
    - feedlots
    - manufacturing facilities activities
    - construction activities
    - waste management and recycling facilities

- automotive-related businesses
  - gasoline stations
  - tire/body repair
  - repair shops
  - paint shops
- selected businesses
  - bulk oil facilities
  - farm supply stores
- electric power generation corridors
- other individual facilities
  - zoos
  - lawn and garden services
  - water treatment plants

The first report on the nature and extent of the storm water problem will identify classes of dischargers needing further regulation to protect water quality. A second report to Congress will identify methods to control storm water discharges to the extent necessary to mitigate impacts on water quality.

In summary, then, EPA's program to deal with discharges of storm water from industry and municipal separate storm sewers is prescribed by the Water Quality Act and implemented through a series of regulations defining application requirements leading to the issuance of NPDES permits. These permits will require compliance with quantitative limits on specific pollutants and qualitative requirements in the form of BMPs.

4.5 National Combined Sewer Overflow Strategy

An even more challenging problem facing EPA is controlling discharges from combined sewer overflows through the permit process. Many of the same challenges present with separate storm sewers are present with CSOs. How do we cost-effectively deal with highly variable discharges of untreated sewage mixed with storm water and industrial waste water discharged from some 15,000 overflow points in some 1200 combined sewers throughout the nation, to bring them into compliance with the technology-based <u>and</u> water-quality based requirement of the Clean Water Act? The question certainly has no simple answer. The initial approach is to develop a national CSO control strategy.

POLLUTION CONTROL IMPLEMENTATION

The National CSO Control Strategy was signed on August 10, 1989 and appeared in the Federal Register on September 8, 1989. One of the first observations made by EPA was that many States and cities were not able to identify where their CSOs are. Some EPA Regions and States have not adequately permitted their CSOs and some have not addressed them at all. Consequently, the strategy starts at the beginning and requires States to develop and submit to EPA CSO permitting strategies by January 15, 1990. These State strategies should identify the CSOs by city, street, intersection or manhole for example, determine their permit status, and establish priorities for permit issuance to Publicly Owned Treatment Works (POTWs) and individual CSOs. The inventory, permit status and priority listings are basic to the ultimate success of the program to address CSOs through permits.

Before listing the objectives of the CSO strategy, it is useful to state some assumptions and provide some definitions critical to an understanding of the CSO control strategy. CSOs are flows from a combined sewer in excess of the sewer capacity, that do not undergo treatment at a Publicly-Owned Treatment Works (POTW). CSOs <u>are</u> point sources subject to NPDES permit requirements. CSOs <u>are not</u> by-passes of the POTW. CSOs <u>are not</u> subject to the secondary treatment requirements for BOD and TSS removal as are POTWs. CSOs <u>are</u> subject to the technology-based requirements similar to industrial discharges (BPT, BCT and BAT) and State water quality standards.

The objectives of the national CSO control strategy are:

1) to ensure that CSO discharges occur only in wet weather (e.g to eliminate dry weather overflows);

2) to bring CSOs into compliance with technology-based and water quality-based requirements; and

3) to minimize the water quality, aquatic biota and human health impacts of CSOs.

These are ambitious objectives. Just as the U.S. did not reach the goal of attaining secondary treatment of domestic sewage overnight, neither will it solve the CSO problem overnight.

Technical and cost considerations are significant and real. Many cities face growing costs in the face of declining revenues. The construction grants program is phasing out. By their very nature, CSOs are most common in the older, larger cities, since they are largely serviced by combined sewer systems. New CSOs are rare, as new areas are serviced by separated sewer systems. The older cities are relatively less able to accept additional costs, due to their tax base. Sewer separation may be neither feasible nor desirable for many cities and other technologies, for CSO control may be technically feasible, but may not be cost effective. Certainly, providing adequate treatment for, or eliminating CSOs will take many years.

Despite the magnitude and complexity of the CSO problem, the national strategy is a long-needed first step toward a long-term solution. The strategy prescribes minimum technology-based requirements for all CSOs. These include:

- proper operation and regular maintenance programs,
- maximum use of the collection system for storage,
- optimization of pretreatment programs,
- maximization of flow to the POTW,
- control of solids and floatables, and
- prohibition of dry weather overflows.

Additional control measures than these minimum requirements could be required to bring CSOs into compliance with more stringent technology-based requirements and water quality standards.

EPA is currently drafting technical guidance to complement its national CSO strategy. The guidance will contain information on source controls, such as O&M procedures and BMPs, as well as treatment technologies, such as detention basins and swirl concentrators. An initial guidance document was completed in early 1990.

4.6 Conclusion

In conclusion, the EPA's approach to addressing the storm water pollution problem through the NPDES permit program in the United States is comprehensive. It addresses direct and indirect discharges from industry, urban runoff from cities and the identification

and treatment or elimination of combined sewer overflows. It is recognized that the problem is complex and that cost-effective solutions will be technically challenging. But the EPA has begun to aggressively attack the problem in a coordinated and formal manner.

Editors' Note:

EPA released the Final Regulations for the NPDES permit application requirements for Storm Water Discharges on November 1990. The Final Regulations were modified on March 21, 1991. The NPDES permits for discharges from municipal separate storm sewer systems include: a requirement to effectively prohibit non-storm water discharges into the storm sewers; and controls to reduce the discharge of pollutants to the maximum extent practicable (including management practices, control techniques and system, design and engineering methods, and other provisions appropriate for the control of such pollutants). EPA or authorized NPDES States may issue system-wide or jurisdiction-wide permits covering all discharges from a municipal separate storm sewer system (U.S. EPA, 1991).

EPA will publish its guidance manuals on combined sewer overflows as two separate documents (a permit writers guide and a technology guide) some time in the future. They have undergone several major edits and drafts over the past two years but are still not in a sufficient final state to even be considered as a draft (A. Eralp, personal communication, March 1992).

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CHAPTER 5

Sizing Detention Facilities and Water Pollution Control Plants For The Humber and Don Sanitary Trunk Sewer Systems

Clint Edmonds and Hugh G. Fraser

ABSTRACT

The Metropolitan Toronto Sanitary Trunk sewer system receives inflow/infiltration (I/I) that increases during wet weather periods due in part to the existence of some combined sewer systems. The results are incidents of combined sewage overflows (CSO) and sewer surcharge causing basement flooding. Programs involving sewer separation, which in recent years have been supplemented by storage solution, have been implemented to ameliorate the problems.

As part of the Metro Works responsibility to provide trunk sewerage and sewage treatment services, a study was undertaken to assess the detention storage and increase in pipe capacity required to eliminate basement flooding and to reduce the frequency of CSO. Integral with this work was an assessment of the impact of CSO controls on the operations of the associated water pollution control plants (WPCPs).

Beginning with land use and population data, system data, sewer flow monitoring results and operating data from the sewage treatment plants, estimates of size and cost were made for the facilities that would be required to achieve the objectives.

Dynamic models of the functioning of the sewer systems, and the removal rates of Biochemical Oxygen Demand (BOD) and suspended solids at the water pollution control plants, were developed, calibrated and used as analytical tools.

The models were used to determine an optimal scheme for treating CSO's. This involved assessing the effect of storage and regulator settings on the trunk sewer system and WPCP performance. In general it was found that detention of CSO with a relatively slow release to the sewer system and WPCP provided the least expensive method for treating combined sewer overflows.

CHAPTER 5

5.1 Introduction

UMA Engineering Ltd. was retained by the Metropolitan Toronto Works Department to assess the capacity of the Humber and Don trunk sanitary sewer systems with a view to developing alternatives for mitigating basement flooding and controlling combined sewer overflows. An important feature of the assignment was to evaluate the impact of remedial measures on the sewage treatment plants serving each collection system. One study, the Humber, was completed in 1988 (UMA Engineering, 1988) and the other, the Don, in 1989 (UMA Engineering, 1989).

The Humber drainage area (Figure 1), about 210 km^2, is serviced by storm, sanitary and combined sewers. The sewage collected is transferred to the Humber Water Pollution Control Plant on Lake Ontario. At the treatment plant, there are by-passes which will divert raw sewage and primary treated sewage from further treatment processes, as necessary, to protect the functioning of the plant. In addition, there are regulators in the collection system which will allow excessive combined sewage resulting from stormwater inflow and infiltration to be directed to local water courses. At times sewer surcharge is responsible for basement flooding. The Don drainage area (Figure 1) system has many of the same characteristics. It is about 265 km^2 in area and it also has sanitary, storm and combined sewer systems. Regulators permit overflow to the local environment. The treatment processes at the Main Water Pollution Control Plant are protected by by-passes. In both drainage areas there are plans for development and redevelopment, mainly at the upper ends of the system. They include developments at York University, the Downsview Airport and the redevelopment of the Yonge, Sheppard, Finch area.

Metro Works is responsible for trunk sanitary and combined sewer services, as well as sewage treatment. These trunk systems have been identified on more than one occasion as being partially responsible for the undesirable water quality characteristics in local water courses and along the lake front. As a consequence Metro undertook, through our studies, to develop an understanding of the sewer systems as a basis for reviewing potential solutions to the surcharge and combined sewer overflow problems. The purpose of the studies was twofold: what are the capacities of the system now? and, what capacities are needed? The basis of study incorporated the following conditions:

- the treatment plants will continue to meet MOE effluent quality standards with whatever solutions are developed;

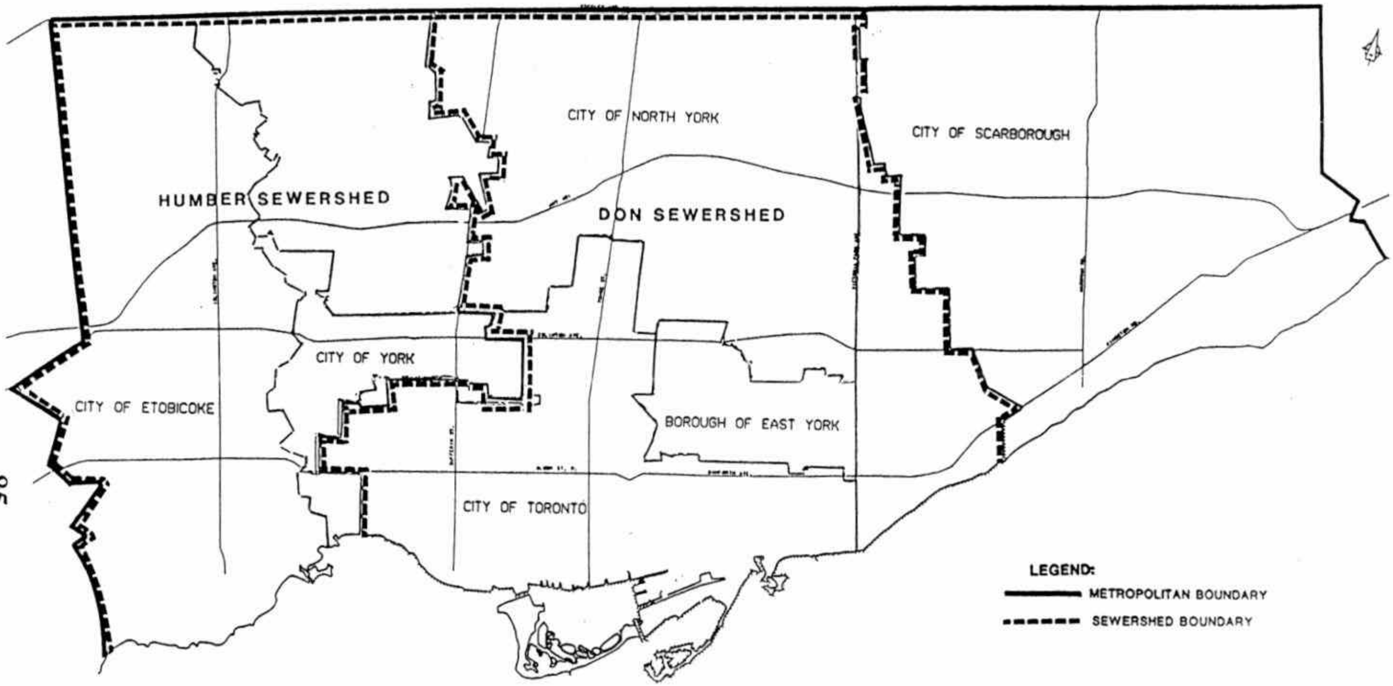

Figure 1: Don and Humber Sewersheds within Metropolitan Toronto

- the CSO frequency will be reduced; and
- basement flooding will be eliminated.

With this purpose in mind, the objectives of the work included:

- understanding of the system operation;
- determination of the impact of population growth;
- identification of the solutions available to resolve the capacity problems, including both storage and conveyance;
- assessment of the impacts of the solutions on the sewage treatment plants; and
- estimates of the costs of solutions.

5.2 Sewer System Modelling

For analyzing a large trunk sewerage system such as the Humber and Don sewersheds, a planning level model is required, which is sufficiently comprehensive to assess all the flow components. In this study, a single event planning model was adapted for assessing the sewer system capacity and flows to the sewage treatment plant. It was used to determine hydrographs for both dry and wet weather conditions.

Essential to the application of a reliable model is the need to have good flow measurement. Metro Works has undertaken extensive flow monitoring throughout the catchment. The collected data were thoroughly analyzed and employed in the development, calibration and verification of the model.

For simulating the dry weather flow, a dimensionless hydrograph was developed from the measured flows. When combined with the population data, per capita flow generation rates and industrial flow generation rates, dry weather flow hydrographs were predicted for each catchment area. The catchment flow hydrographs were combined and routed to obtain hydrographs throughout the system. Measured flows were compared with modelled flows, at the various flow monitoring locations in the system, to ensure proper model calibration.

Of particular importance is the operation of the system during wet weather conditions. In sanitary areas two sources of rainwater entering the sanitary sewers are considered. The first is direct rain-water inflow from roof leader connections, or illegal connections. The second is rain-water infiltration, where the storm water seeps through the soil into foundation collectors or the sanitary sewer. The quantity of infiltration/inflow (I/I) was determined from an analysis of the flow measurements during rainfall periods. It was found that from one to nine percent of the rainfall volume could enter the sanitary system.

The response of the system to the different flow components was modelled using two triangular unit hydrographs, one to describe the inflow response and the other the infiltration. These modelled responses were combined with the dry weather flow to obtain the total flow for a sanitary sewer catchment during a rain event. Excessive wet weather inflow/infiltration can result in the sanitary sewer system becoming surcharged and may result in basement flooding.

For combined sewer areas the surface drainage system is directly connected to the sewer. Consequently, the runoff volume can be 30-70% of the rainfall volume and the runoff response is usually very rapid. To model this, an existing rainfall/runoff response function (P'ng, 1982; Wisner and P'ng, 1983) was used. The runoff hydrograph so produced was combined with the dry weather flow to obtain the total hydrograph from the combined catchment.

To obtain the flow response, through the system, the hydrographs from individual catchments were added and routed through flow regulators and sewer pipes as dictated by the system configuration.

5.3 Water Pollution Control Plant Modelling

Computer modelling of sewage treatment plants is relatively new and can assist plant engineers in obtaining a better understanding of the system operation during wet and dry periods. Adopting this approach for assessing WPCP performance raises other questions such as; How should WPCPs be rated? What should be considered a sewage bypass? How should WPCP costs be determined? Traditionally, plants are rated using a function of dry weather flow. For design purposes, factors are applied to the selected flow rating to account for diurnal and other temporal variations, some stormwater inflow and infiltration, and other sewage sources e.g., industrial contributions. In the Humber plant we found that the factor that one would apply to the average dry weather flow to account

for diurnal variation, would be about 1.3 to 1.4. To account for some infiltration/inflow contribution, judgement has been used bringing the total factor up to 1.8 to 2.0 depending upon who applies the judgement.

In a sewage system that includes combined sewers, where there is a desire to protect the process units, a different philosophy may be preferred. The pattern of normal temporal variations is not the controlling feature. The shape of the influent hydrograph to the sewage treatment plant can change markedly because of wet weather infiltration/inflow. As a result the dry weather flow is not a significant basis for design criteria, if effluent quality requirements are to be met under wet weather conditions. For these studies, the basis for the design criteria was the sewage peak flow (Q) to the plant and the duration (T) for which it could be sustained, while maintaining effluent quality compliance requirements (Figure 2).

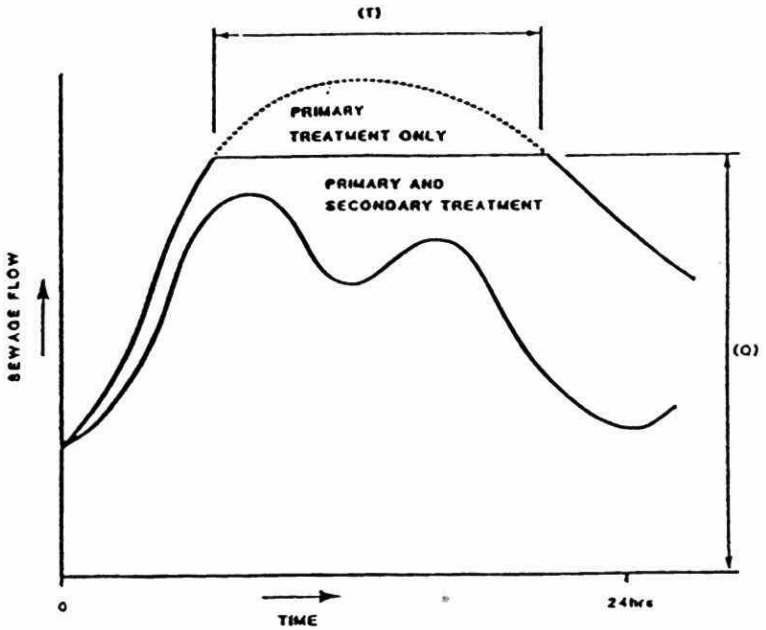

Figure 2: Rating of Sewage Treatment Plants Experiencing Signigicant Inflow/ Infiltration Effects

The influent hydrographs shown in the figure are presented as typical diurnal and storm conditions respectively. Implementation of CSO control measures will change the shape of the hydrograph by diverting more sewage to the sewage treatment plant. Normally, a treatment plant would be designed to treat all of the diurnal flow. With the storm condition, the impact of a by-pass ahead of secondary treatment on the shape of the hydrograph is indicated. Families of such curves, that depend on the specific characteristics of the systems, can be prepared for different storm scenarios. In order to use this concept it was essential to have available a model which would describe the operation of the sewage treatment plant for a given influent hydrograph, and to provide output in terms of effluent quality. We obtained, adapted and calibrated such a model (Busby, 1973). Its relative simplicity was useful for running through many storm condition scenarios. The inputs were hydrographs, sewage strength, return activated sludge ratios, sludge wasting strategies and like items. The outputs were effluent flow rate and quality. Also available were outputs describing intermediate parameters such as settled sewage flow, dissolved oxygen concentrations in aeration tanks and sludge blanket heights in the final clarifiers.

The model can be operated to work with by-passes and it will blend by-passed flow and secondary effluent to obtain a composite effluent quality. This feature is important in light of the emerging philosophy of the Ministry of the Environment (MOE), which is, that no by-passes will be allowed. In reality, all systems are designed for some maximum event and by-passes will occur. Our understanding of their philosophy, is that if by-passing, or partial treatment does occur, the by-pass quality will be blended with the quality of the fully treated sewage in establishing whether effluent quality requirements are met.

A matter which had to be resolved was: is an overflow to a local watercourse considered to be a by-pass if it is located close to the treatment plant, and a combined sewer overflow if it is further upstream from the sewage treatment plant? The basis upon which the model was operated was that sewage discharged to the environment ahead of primary treatment was not incorporated in predictions of effluent quality. In that respect it was comparable to a combined sewer overflow. Partially treated sewage, by-passed after primary treatment, was used in the prediction of treated effluent quality.

It was necessary to establish a common reference point for assessing the implications of CSO control measures on the sewage treatment plants. The reference chosen was the effluent quality compliance requirement. The impact of by-passed, primary treated sewage on composite effluent quality, under the storm conditions studied, is to cause

exceedances beyond effluent quality compliance requirements. Thus, before the impacts of CSO and basement flooding control measures could be assessed, the impact of by-passing an effluent quality (under storm conditions without the controls) had to be nullified. This was done by simulating incrementally greater treatment capacity in the model until the effluent quality was satisfactory. With conditions normalized, the hydrographs that reflected the influence of CSO control measures were then applied to the model. Again treatment plant capacity was incrementally increased until a satisfactory effluent quality was predicted.

An important aspect of the model that was not resolved to our full satisfaction was the relationship between flow rate and suspended solids concentration in the effluent of the final clarifiers. The literature does not provide good definition of the settling quality of activated sludge relative to descriptions of its condition as it leaves the aeration tanks and of the subsequent conditions existing in the final clarifiers. A regression analysis of influent and effluent quality was eventually used to simulate final clarifier performance. It worked satisfactorily for the purpose for which it was intended.

The data base should be an item of major concern in any operating sewage treatment plant. The model that we used operates on a basis of a short, less than 30 minutes, time increments. The data usually available at any operating treatment plant, does not meet this requirement. The model had to be calibrated on 24-hour composited samples. This gave rise to a second concern. Analytical results from composited samples include errors in sampling and analysis. Consequently, more confidence was placed in the longer term trends provided by the model, and by which it was calibrated, than in specific empirical data points or short term series of data points. It was concluded that with a calibrated model providing reasonable predictions, an effective and economic sampling program could be developed. Regular daily 24-hour composite sample analysis, may not be needed.

Cost estimating is another highlight worthy of mention. One method of providing water pollution control plant costs, is to use unit values such as $5 million per MGD, etc. There is a built in assumption that what is meant by a gallon in the unit value is commonly understood. Usually it relates to a function of the average dry weather flow described earlier. In this study, when the performance of the treatment plant was being assessed under wet weather conditions, it was not possible to relate to the traditional costs quoted for sewage treatment. The factors governing treatment plant performance were the peak flow and its duration. They do not relate meaningfully to average dry weather flow. Consequently, it was necessary to assess directly the cost of the tankage and equipment

(Hydromantis, 1985) needed to treat the sewage at this peak flow rate and associated duration.

5.4 Impact of CSO Control

Several methods can be used for controlling combined sewer overflows and the associated pollution. These include storage, changing regulator settings, sewer separation or providing some treatment using swirl concentrators, settling tanks or disinfection. The options presented here are storage and regulator adjustment. When these options are used to obtain a selected level of combined sewer overflow control, a wide range of storage and regulator settings may be selected. To simplify the analysis it was conducted in two parts; the first determined the storage volumes required for selected levels of runoff control assuming a fixed regulatory setting; the second examined the effects of changing the regular settings, on the sewer system, the water pollution control plant and the volume of storage.

5.4.1 CSO Storage

Storage sizes were determined to provide desired levels of runoff control. The term "runoff control" used here refers to the percentage of wet weather runoff in combined sewer systems that is intercepted and conveyed to the WPCP for treatment. Two levels of control were selected; the first a 90% level of runoff control and the second to control the combined sewer overflows to an average once per year (about 98% runoff control). The size of the storage facilities for these runoff control levels were obtained using the continuous simulation model STORM (Hyd. Eng. Cen., 1977). The total interception rate was set at the peak dry weather flow (PDWF) plus an I/I allowance of 0.26 l/s/ha. This rate was selected because the trunk sewers are designed to convey this flow. When expressed as a ratio of the average dry weather flow (ADWF) this interception rate was found to vary between 1.7 and 3.3.

The total storage requirements varied at each of the flow regulators. This is because of the different catchment sizes and variations in land use. The CSO storage requirements for the two selected levels of runoff control are shown on Figure 3. The total volumes were 127,000 m^3 for 90% runoff control and 242,000 m^3 for one CSO/year. When they are expressed as an equivalent depth over the combined sewer catchment area it was found that about 7 mm of storage was required to achieve 90% runoff control and 11 mm

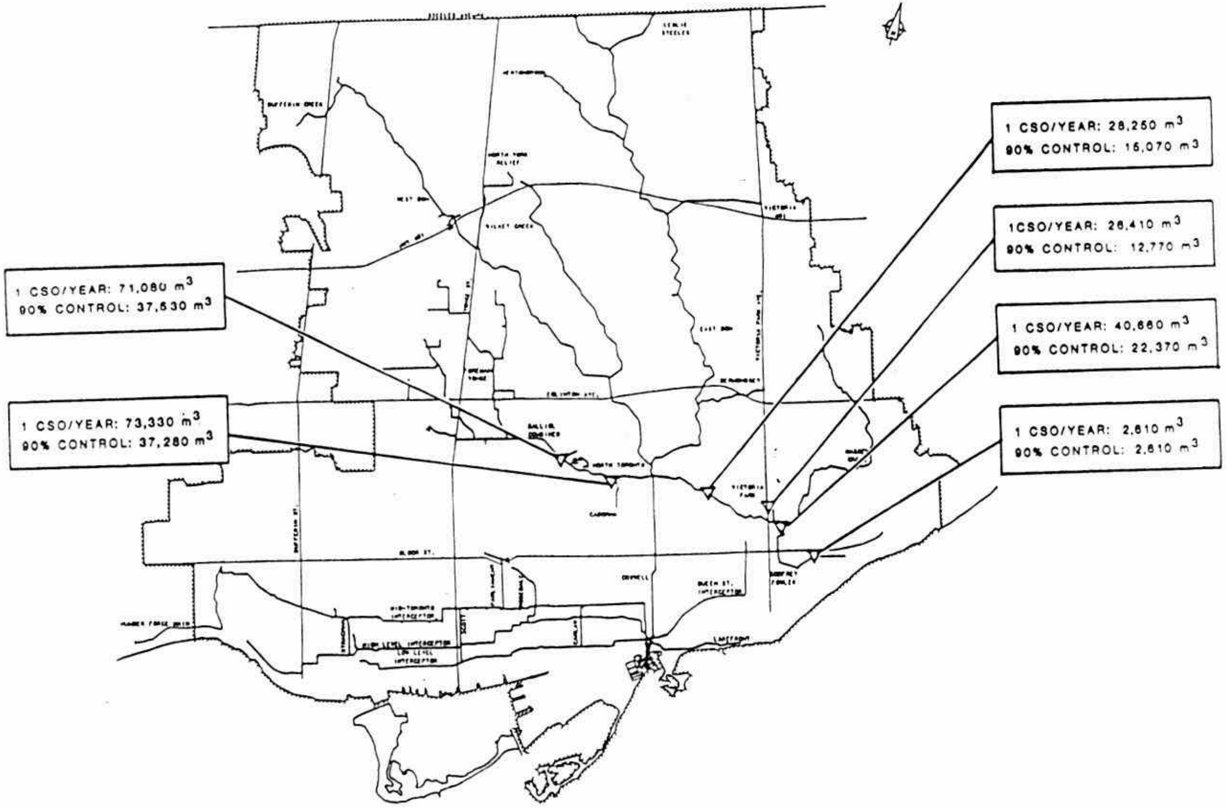

Figure 3: Location and Size of CSO Storages on the Don Sewer System

of storage for one CSO/year. The total cost for constructing these CSO storage was estimated at about $43 million and $79 million respectively.

5.4.2 Regulator Adjustment

An alternative method of reducing the frequency and volume of combined sewer overflows is to increase the interception rate. This was done by adjusting the regulator settings in the computer models to 5 times and 10 times the average dry weather flow. It was found that even with these substantially higher interception rates some storage was still required to reduce the CSO frequency to an average one per year. When the interception rate was increased to 10 times the ADWF a storage volume of 87,000 m^3 is required or an equivalent depth of about 5 mm. These higher interception rates result in higher flows in the trunk sewer system which requires that the trunk sewer conveyance capacities be increased. The total cost for the storage was estimated at $44 and $29 million for the interception rates of 5 and 10 times ADWF respectively. The sewer system capacity improvements were estimated to cost $4.3 million (5 x ADWF) and $7.2 million (10 x ADWF) (Table 1). In conclusion, if one were only to examine the sewer system improvements it would appear that a high interception rate and a relatively low quantity of storage is the least cost option.

5.4.3 Water Pollution Control Plant

The computer models described earlier were to simulate the impact of the various CSO control alternatives on the sewer system and water pollution control plant. The system was modelled using an event that occurred on September 14, 1982. This event was selected because of its characteristics:

- its approximate four hour duration is similar to the time of concentration for the sewershed;
- rain data was available from five gauges throughout the watershed; and
- the rain volume which varied from 37 mm to 55 mm would cause the CSO storages to be exceeded and therefore result in a heavy loading on the sewage system and the sewage treatment plant.

TABLE 1
COST COMPARISON FOR
CSO CONTROL ALTERNATIVES

	SYSTEM IMPROVEMENT COST			
	90% 1.7 - 3.3 x ADWF (1) ($M)	1 CSO/YEAR 1.7 - 3.3 x ADWF ($M)	1 CSO/YEAR 5 x ADWF ($M)	1 CSO/YEAR 10 x ADWF ($M)
CSO STORAGE	43.3	79.0	44.4	29.1
SYSTEM CAPACITY (2)	23.0	23.0	27.3	30.2
TOTAL SEWER SYSTEM	66.3	102.0	71.7	59.3
STP (3)	317.0	317.0	365.0	525.0
TOTAL	383.3	419.0	436.7	584.3

Note: ADWF = Average Dry Weather Flow

(1) The regulator settings varied as a function of ADWF since they were selected at peak dry weather flow plus 0.26 l/s/ha.

(2) The base cost for upgrading the existing sewer system was $23M.

(3) The base cost for upgrading the existing STP to handle the Sept. 14/82 storm was $300M.

When this storm event was simulated on the existing system it was found that the existing plant would have to be expanded so that the effluent water quality would not exceed the compliance. It was estimated that additional secondary treatment capacity as well as solids handling capability at the plant would have to be improved at an estimated cost of $300 million. Consideration was then given to providing treatment for the additional waste water resulting from providing a higher level of CSO control. The effect on the flow hydrographs to the Main WPCP for the CSO storage options of 90% and one CSO/year is shown on Figures 4 and 5. On the day of the storm the peak flows are slightly higher than for existing conditions. However, they are the same for each CSO control option. Following the storm, the discharge from the storage facilities provided for the one CSO/year takes longer than for the 90% runoff control. With CSO storage in place, the waste water volume to be treated increases by about 25% during and immediately after the storm event. It was estimated that with an upgraded plant no additional secondary treatment capacity would be required. However, the solids handling capability would have to be increased, due to the extra Wet Weather Flow (WWF) being treated, at an additional cost of $17 million (Table 1).

The effect of adjusting regulator settings to 5 and 10 times the average dry weather flow impacts on the sewer system but especially on the water pollution control plant where the effect is pronounced. At 5 times ADWF the peak flow increases above existing peak is 15%, and at 10 times ADWF the peak flow increase is 36% (Figures 6 and 7). With the interception rate at 5 times the ADWF, additional secondary treatment and solids handling capability is required at a total estimated cost of $340 million. The plant expansion, to achieve adequate treatment with the combined sewer regulators, set at 10 times the ADWF was estimated at $500 million.

The CSO control measures, improved system capacity and sewage treatment plant costs were integrated to obtain an overall cost comparison (Table 1). It shows that utilizing upstream storage for CSO control is more cost effective than increasing the flow regulators interception rate and the sewage treatment plant capacity. It was concluded that cost effective CSO control should be provided by constructing storage rather than expanding the sewage treatment plant.

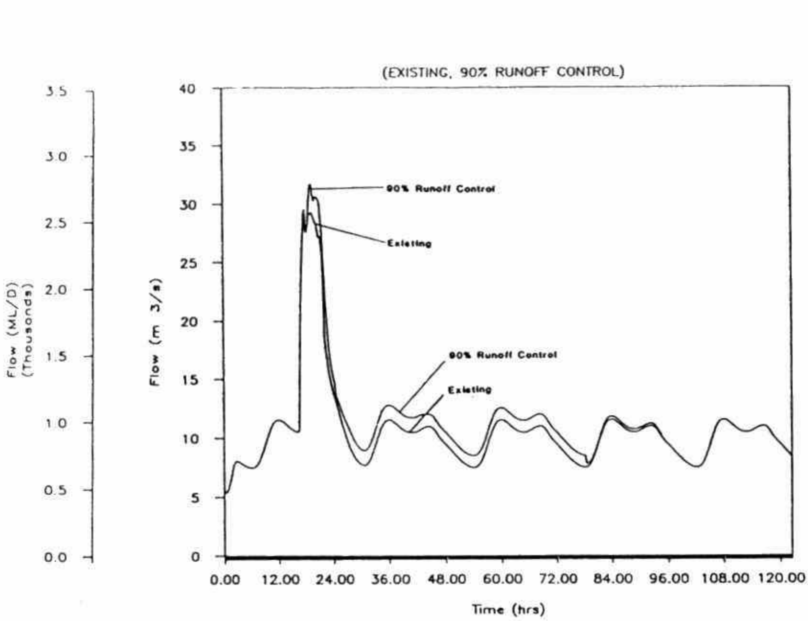

Figure 4: Hydrographs at the STP

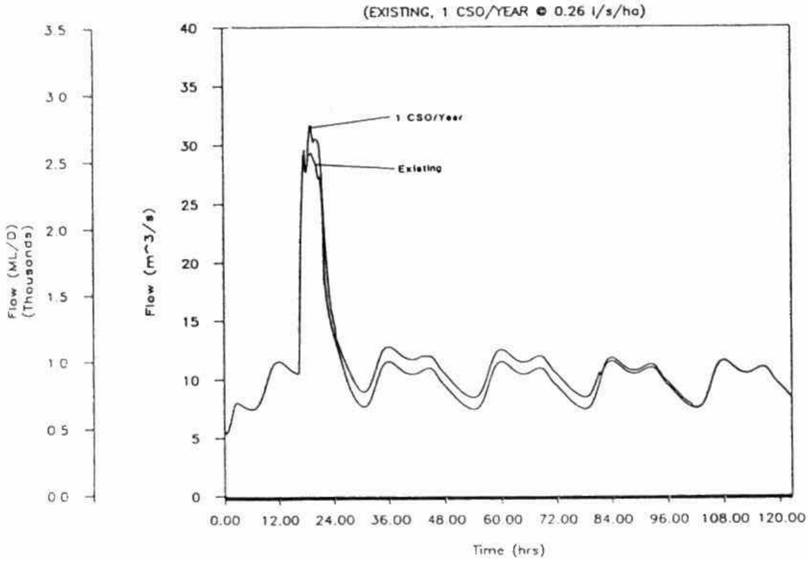

Figure 5: Hydrographs at the STP

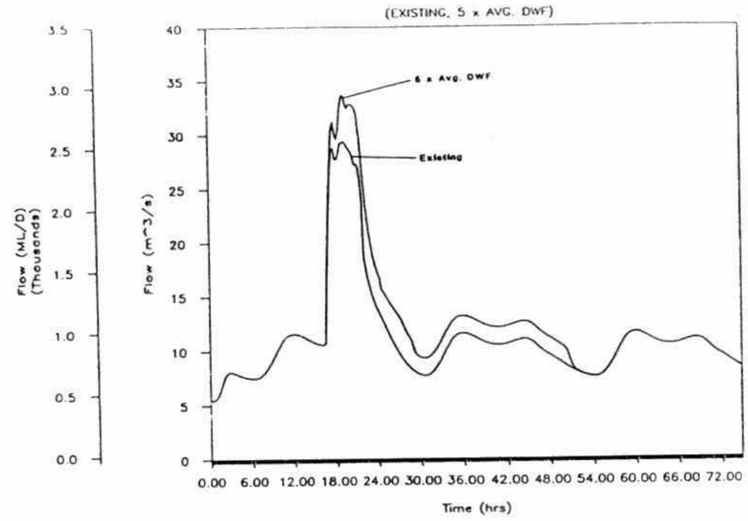

Figure 6: Hydrographs at the STP

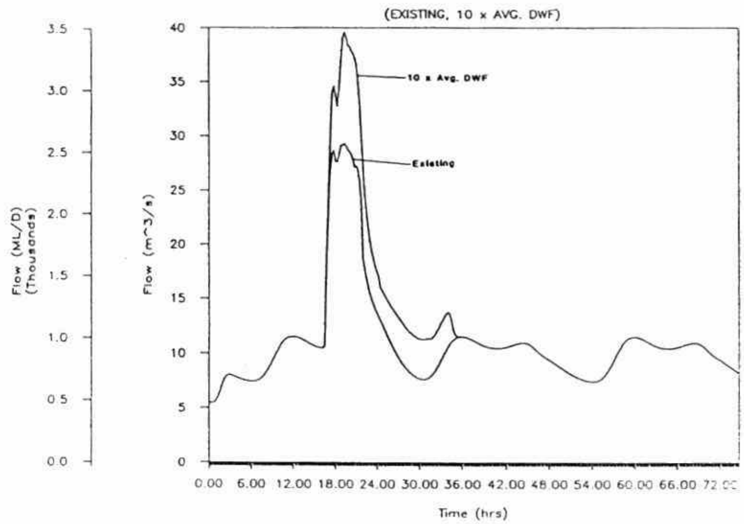

Figure 7: Hydrographs at the STP

5.5 Conclusions

This paper has discussed some of the findings related to the analysis and modelling of the Humber and Don sewerage systems in Metropolitan Toronto. In particular, the findings related to the improvements required to optimize the level of CSO control and water pollution control plant performance are presented. Our conclusions are as follows:

1) When rating a water pollution control plant's performance during wet weather periods, consideration should be given to the flow rate and flow duration.

2) When costing water pollution control plant expansion for wet weather flows, the cost should be determined on the basis of equipment additions rather than a standard unit cost for each flow unit treated.

3) A large component of the existing flows to the sewage treatment plants during wet weather periods is due to inflow/infiltration. The WPCP expansion costs to achieve an adequate effluent quality during wet weather periods are significant.

4) Prior to selecting a particular CSO control level, the costs and benefits should be understood. The costs of storage and treatment increase exponentially with higher levels of CSO control.

5) To achieve a particular level of CSO control the overall costs are higher if the interception rate is increased rather than providing storage.

6) When assessing CSO control measures it is important to examine the costs as they affect to the whole sewerage system.

5.6 References

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CHAPTER 6

Proposed Policy for CSO Abatement to Manage Sanitary Sewage Collection and Treatment In Wet Weather in the Municipality of Metropolitan Toronto

Kevin T. Loughborough

ABSTRACT

Studies, completed as part of the Toronto Area Watershed Management Strategy (TAWMS) and the Waterfront Water Quality Improvement Program (WWQIP), have recommended pollution control measures which will impact on Metropolitan trunk sewers and treatment plants. Area municipalities have drafted pollution control strategies which consist of additional separation and also detention of combined sewage to reduce basement flooding and combined sewer overflow to watercourses and the waterfront.

Metropolitan Toronto (Metro) has developed through consultation with the area municipalities a proposed policy which also includes guidelines to manage sewage collection and treatment in wet weather. Under the proposed policy, Metro will construct additional treatment capacity to handle existing wet weather flows and detained combined sewer overflow in a phased program tied to the pace that area municipalities proceed with implementation of their pollution control strategies. Subject to enabling legislative amendments, Metro would contribute to the cost of detention proposals submitted by area municipalities to reduce CSO provided certain requirements are met.

6.1 Introduction

Metropolitan Toronto (Metro) has a residential population of approximately 2.2 million and an employment population of approximately 1.2 million people within a land area of 632 km^2. It is serviced by partially and fully separated sanitary sewers draining to four wastewater treatment plants (Lakeview, Humber, Main and Highland Creek) on Lake Ontario and one much smaller treatment plant (North Toronto) on the Don River. Metro,

in cooperation with the area municipalities and the Province is endeavouring to improve water quality in watercourses and along the Lake Ontario waterfront. Combined sewers serve approximately 8 percent of the Humber Water Pollution Control Plant (WPCP) drainage area and approximately 21 percent of the Main Water Pollution Control Plant drainage area.

Significant wet weather flows cause basement flooding in combined sewer areas and also in sanitary sewer areas where foundation drains are connected to the sanitary sewer. They result in combined sewer overflows to the rivers and Lake Ontario and reduced effluent quality at wastewater treatment plants. Treatment plant effects include both plant bypasses and reduced treatment efficiency due to the hydraulic load.

As the operator of the trunk sewers and treatment plants, Metro's goal is to eliminate extraneous wet weather flow wherever possible. One way is sewer separation which has been cost-shared by Metro. Where elimination is not practical, area municipalities have proposed detention of wet weather flows primarily to reduce basement flooding, but also to reduce combined sewer overflows. Metro wants to manage the release of these detained flows to relieve overloading of trunk sewers and treatment plants and to reduce plant bypasses and combined sewer overflows. Metro is interested in participating with other levels of government in reducing CSOs to improve recreational water quality in particular along the Eastern and Western Beaches on Lake Ontario. Reduction in overflows containing fecal coliforms, viruses, other contaminants, and debris such as floatables is sought to meet Provincial Water Quality Objectives.

The following photographs (Figures 1 to 6) show the wide range of land uses which comprise the Metropolitan Toronto Waterfront from west to east.

Land uses along the Metropolitan Toronto waterfront have been changing from predominantly rail, port and heavy industrial uses toward greater emphasis on commercial, residential, recreational and park uses. Other initiatives have included concepts for redesigning the waterfront including transportation links and landscape amenities (Royal Commission, 1990). Water pollution control standards have to be improved and implemented to keep pace with these changes in land uses and improvements in amenities of the waterfront. A comprehensive approach to the clean-up is required. No single initiative is sufficient. A concerted effort by all concerned is required to achieve desired improvements.

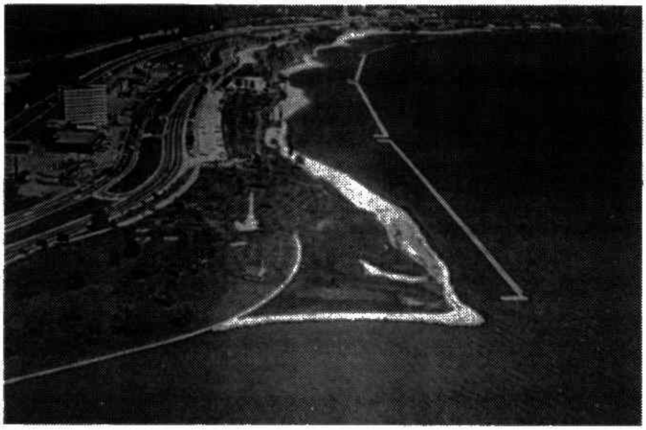

Figure 1: Western Beaches (with Humber River in Foreground)

Figure 2: Recreational Uses - Ontario Place (landfill)

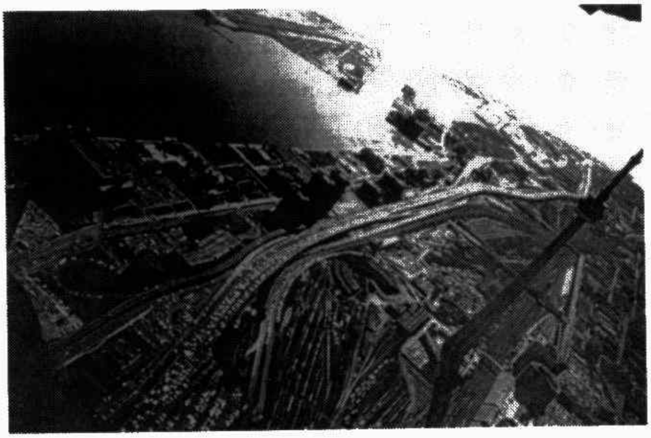

Figure 3: Core Area - Ontario Place, Harbourfront, Railroads

Figure 4: Ashbridges Bay, Toronto Harbour, Don River Outlet, Port Area, Industrial Uses, Core Area Commercial

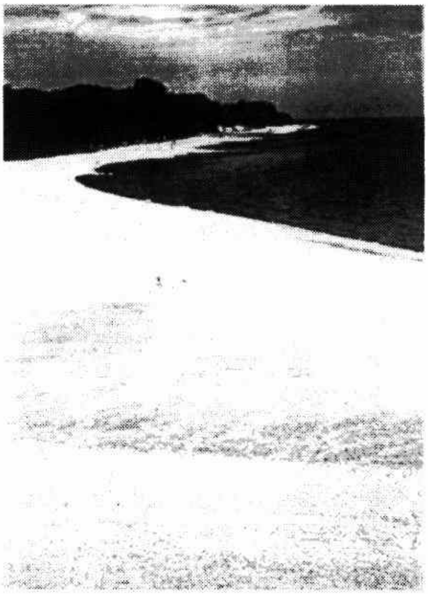

Figure 5: Eastern Beaches

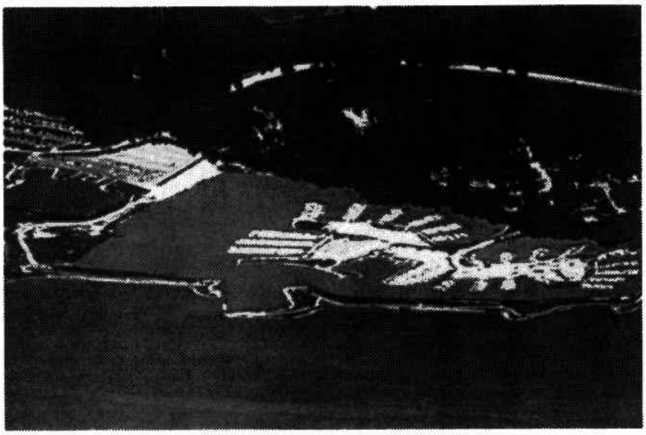

Figure 6: Bluffers Park, Scarborough

An overall strategy for improving water pollution control in the Humber and Don River trunk sanitary systems has been developed. Wet weather combined and sanitary flow management will be a part of the work plan for improvement of recreational water quality. The proposed strategy for reducing basement flooding and the frequency for CSOs in the Humber and Don trunk systems is outlined by Edmonds and Fraser (Chapter 5). Other tasks include industrial waste control through the identification of priority outfalls, and sewer use by-law enforcement. Other pollution control measures proposed by the area municipalities are described below.

6.2 History of Water Pollution Control Efforts in Toronto Area

To assist in the implementation of some of these pollution control efforts, Metro Works in consultation with the Works Departments of each of the area municipalities and the Ministry of the Environment has drafted a policy to share in the cost of projects proposed by the area municipalities to reduce CSOs. The policy is another part of the overall solution.

It is interesting to review the progress that has been made over the years as a way of placing what we now want to achieve in an overall context. For continued improvement in pollution control in the future a more comprehensive approach will be needed than in the past. As well, the use of the more sophisticated engineering tools now available - large data bases and computer models are essential as the field moves beyond the simpler approaches of the past.

At the turn of the century, the Metropolitan Toronto area consisted of the City of Toronto and surrounding rural townships. There were combined sewers and interceptors in the City and no sewers in the townships. Limited treatment was provided at the treatment plant discharging to Ashbridges Bay.

The capacity of this plant expanded from 33 MGD to its present capacity of 180 MGD in the twentieth century as follows.

POLLUTION CONTROL IMPLEMENTATION

	Primary Capacity (MGD)	Secondary Capacity (MGD)
1912	33	-
1950	84	-
1961	120	aeration + secondary settling (20 mgd).
1989	180	180

After the Second World War, the townships urbanized rapidly (see municipal boundaries given in Figure 7). In 1953 Metropolitan Toronto was formed by an Act of the Ontario Legislature to provide among other things sanitary trunk sewers and regionally-based treatment plants. Trunk sewers were brought into each area municipality to receive flow from local sewers which remained under the jurisdiction of the Area Municipalities which comprised Metropolitan Toronto. Many small treatment plants discharging to the rivers flowing through the area (Humber, Don, Rouge) were replaced with sanitary trunk sewers draining to expanded and new wastewater treatment plants on Lake Ontario.

Initially only sanitary sewers without storm sewers or foundation drain collectors were constructed in the Townships to serve existing buildings on septic tanks. The initial policy was that these sanitary sewers were not to be connected to foundation drains. However, home owners anxious to get rid of sump pumps were allowed to connect foundation drains to the sanitary system before the storm sewers were constructed. Some years later roadside ditches were replaced with curb, gutter and storm sewers.

New subdivisions in the townships were constructed complete with urban road cross sections containing separate sanitary and storm sewers. Foundation drains often were connected to the storm sewer.

In the late 1970s, subdivisions were constructed with storm inlet control and detention facilities. The detention facilities were generally designed to control peak runoff rates to decrease the downstream erosion potential. Sometimes a third separate foundation drain collector was connected to the storm sewer system.

CHAPTER 6

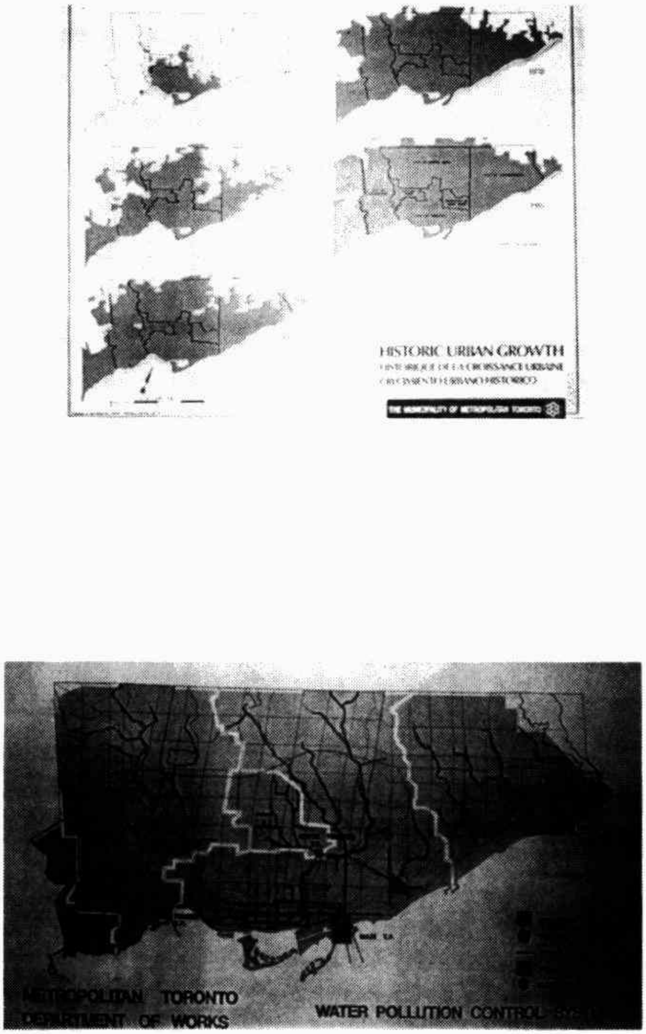

Figure 7: Historical Urban Growth and WPC Systems in Metro Toronto

While rapid development was occurring in the townships, the City of Toronto was experiencing redevelopment pressures. Redevelopment in the City added sanitary flow to the combined sewers potentially resulting in incremental increases in combined sewer overflow (CSO) discharges to receiving water.

6.3 Development of Sewer Separation Policy for Water Quality Control

Combined sewers in the City were overloaded during wet weather, causing basement flooding. The combined system consists of inter-connections and overflows both upstream into storm sewers and downstream to overflow points at water courses and Lake Ontario (see Figure 8). The basement flooding issue spurred the City to develop a comprehensive mainframe computer model of the combined system in the City and to augment sewer separation programs.

In the mid-1960's the City of Toronto embarked on a long-term programme of sewer separation principally to reduce basement flooding. This program was augmented in the mid-1970's by Metro entering into a cost-sharing arrangement for sewer separation. Cost-sharing was initiated for two reasons:

1) in order to reduce storm water reaching the trunk sewers and treatment plants causing plant bypass and impaired effluent quality.

2) in order to reduce the combined sewer overflow.

A policy of full separation was adopted because it was required to completely eliminate basement flooding and combined sewer overflow for any storm intensity. A fully separated sanitary system is independent of storm conditions.

From 1974 to August 1989 a total of $38,581,879.61 was approved as Metro's share of the cost of sewer separation projects undertaken by the area municipalities of the Cities of Scarborough, Toronto and York and the Borough of East York. Hence, by means of sewer separation, Metro has been participating in the control of CSOs since 1974. The total expenditure since the programme began is in excess of approximately $200 million.

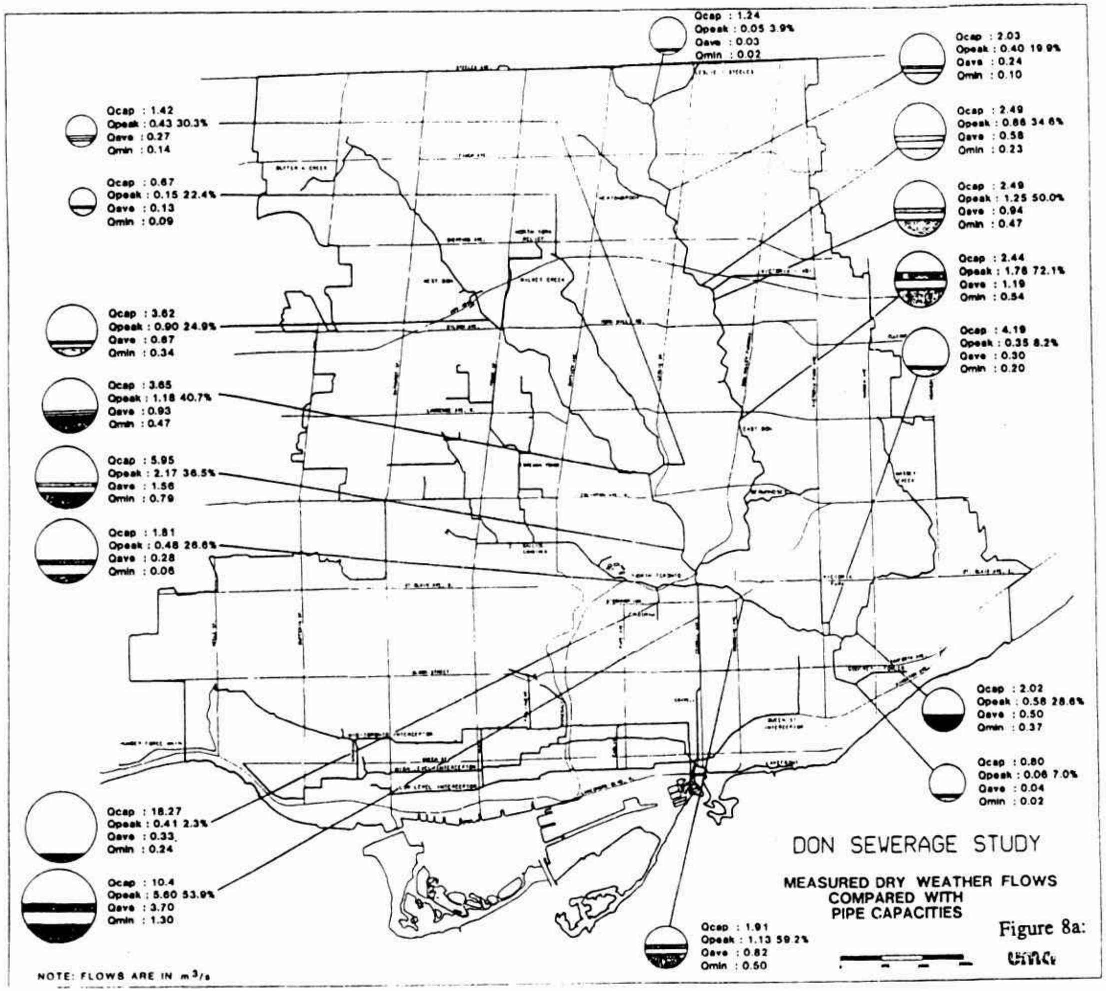

Figure 8a: Measured Dry Weather Flows Compared with Pipe Capacities

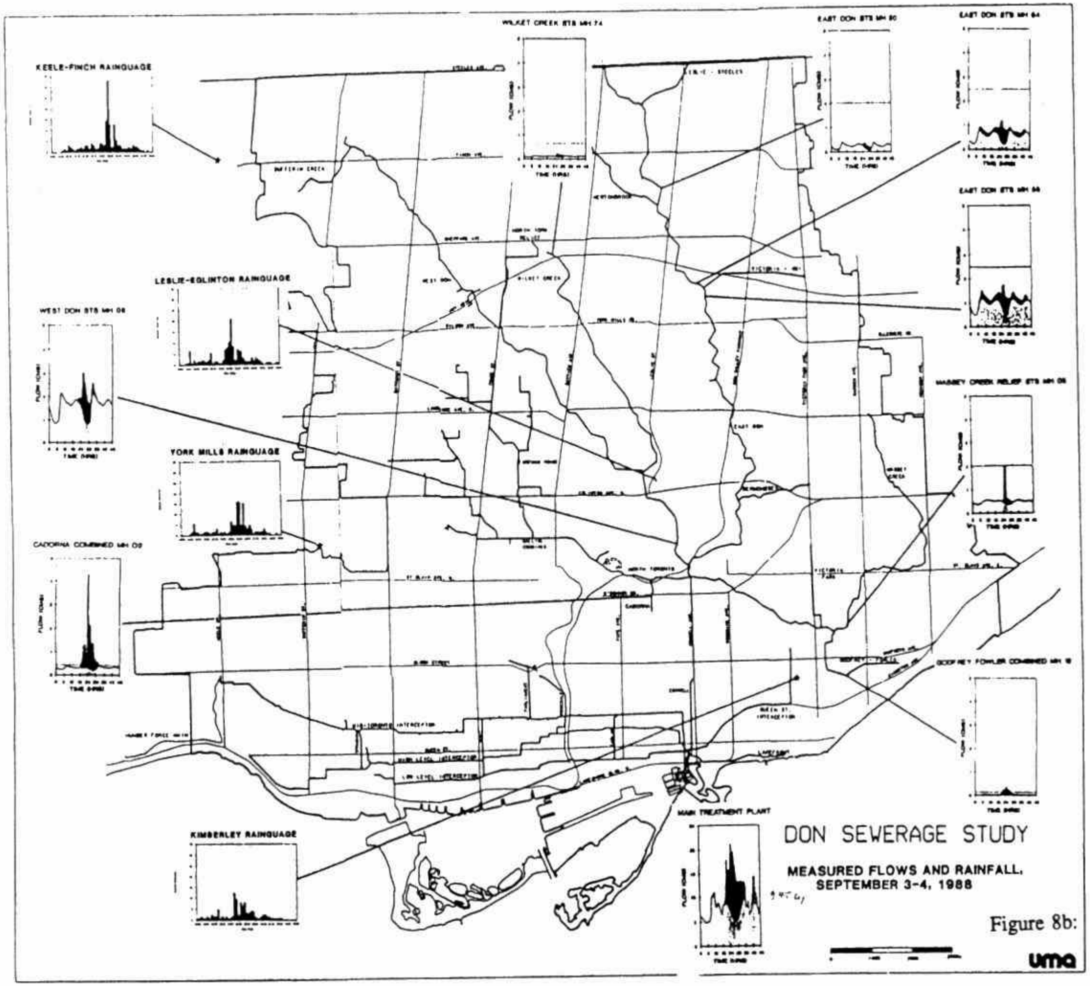

Figure 8b: Measured Flows and Rainfall, September 3-4, 1988

6.4 Alternative Control Methods to Sewer Separation

Due to budget constraints and an increasing interest in finding faster solutions to environmental problems, alternatives to sewer separation were sought as part of the Toronto Area Watershed Management Studies. Faster solutions are required for receiving water quality improvement because combined sewer overflows have been identified as a significant source of pollution in such studies as the Humber River Water Quality Management Plan.

The City of York have been proceeding at a fairly slow pace with sewer separation due primarily to budget constraints. This has caused them to seek a quicker, less costly solution to basement flooding. York's consultant identified inlet control and detention as a means of reducing basement flooding and combined sewer overflow.

Around the same time as the Humber River study, other studies were initiated in other area municipalities having combined sewers. In East York a consultant (Gore & Storrie, 1986) was looking at alternatives to sewer separation and identified detention as an alternative. In Scarborough a consultant (Proctor and Redfern Group, 1987) developed a pollution control strategy which comprised a range of initiatives including sewer separation, inlet control and detention to reduce basement flooding and combined sewer overflow. In the City of Toronto two consultants undertook a review of the trunk interceptor sewers in a joint study for the City and Metro Toronto, which looked at detention to reduce combined sewer overflow at the Eastern and Western Beaches, the Harbour and the Don River.

These sewer system studies raised a very important question: what would be the effect on the quality of the treatment plant effluent, of releasing detained combined sewer flow to the treatment plants after the wet weather had passed. To answer this Metro initiated two studies. The first was a study of the Humber Trunk System and Treatment Plant which was completed in 1988 (UMA, 1988). The second was a study of the Don Trunk System and Main Treatment Plant which was completed in the fall of 1989 (UMA, 1989).

These two studies were the first studies in the Toronto area to analyze vast data bases of continuous flow measurements collected over several years using state-of-the-art flow monitoring equipment located at points throughout the system. These flow measurements were related to continuous rainfall records. Present population and land use information

based on census data, together with future forecasts received from the local and Metropolitan Planning Departments were used together with the hydrology data base to forecast the present and future overflow history of each trunk system.

The Humber Trunk study confirmed that the treatment plant would have to be expanded to handle existing wet weather flow and also to handle release of detained combined sewer overflow. The Humber Trunk study also indicated that detention can be designed to release at a rate not exceeding the rate traditionally included in the design of trunk sewers to convey peak wet weather infiltration of 0.26 L/s/ha. In dry weather, infiltration reduces to negligible values resulting in available capacity in the Humber Trunk system to convey controlled release of detained flows.

Expansion of the Humber Treatment Plant to handle infiltration/inflow experienced under the 5 year storm is estimated to cost $32,500,000. Further expansion of the Humber Plant to treat stored CSO volumes and provide additional dry weather capacity due to population growth is estimated to cost $32,500,000.

6.5 Development of CSO Policy in Metropolitan Toronto

As a result of the trunk system and treatment plant studies and with concern for discharge of untreated or partially treated sewage, Metro Works in consultation with the area municipalities, developed a CSO policy which has been referred by Metro Works Committee to the Area Municipalities for comment. The proposed policy manages sewage collection and treatment in wet weather. It contains the policy recommendations related to:

- trunk sewers,
- detention storage,
- treatment, and
- sewer separation.

6.5.1 Trunk Sewers Nearing Capacity

Some Metro trunk sewers that were designed about 30 years ago for a drainage area that is now almost fully urbanized are nearing capacity according to the trunk system and treatment plant studies. As a result Metro will have to construct additional trunk sewer capacity to accommodate growth as forecast in new 20 year population projections recently adopted by Metropolitan Council.

Since Metro will have to construct additional trunk sewer capacity to accommodate growth, Metro wants to look at comprehensive proposals which also provide improvements in wet weather flow management, greater system security and the ability to drain and maintain existing trunk sewers.

Metro Council recently approved the concept of a new trunk sewer in the Black Creek Sanitary Trunk Sewer drainage area primarily to provide for future growth. This project will probably be a deep tunnel and as such offers opportunities to incorporate additional detention capacity to manage wet weather flow emanating from sanitary sewers with foundation drains connected and also combined sewer overflows from combined sewers in the Black Creek drainage area.

6.5.2 Maintenance of Trunk Sewers

Metro staff also wish to incorporate sufficient capacity to allow the existing trunk sewer to be taken out of service for maintenance and also provide greater system security to reduce the risk of a release of sanitary sewage to the environment in the event of a failure in the existing trunk sewer system.

6.5.3 Allocation of Detention Storage to Sizing Trunk Systems

If in cooperation with the area municipalities Metro decides to include detention capacity in the sizing of trunk relief sewers, then the trunk relief sewer will obviate the need for detention in the corresponding part of the local system. Implementation of the CSO Policy will therefore include coordination of both local and Metropolitan sewer improvement programs.

6.5.4 Treatment of Discharges From Separated Storm Sewer Systems

Under existing legislation Metro treatment plants are not required to treat storm water discharged from separate storm sewer outfalls. They also do not have the capacity. The proposal to treat separate storm water is being addressed in the Toronto Area Watershed Management Strategy and in the formulation of the Remedial Action Plan. On-site treatment measures have been proposed at outfalls of separate storm sewers.

6.5.5 Time Frame for Achieving Full Sewer Separation

Under Metro's proposed CSO policy complete separation is preferred where practical. However, partial separation is all that can be achieved in many instances until storm flows emanating from private property are reduced through the redevelopment process or other means. Metro recognizes that the redevelopment process will take a very long time (100 years or more) to reach a level where significant volumes of wet weather flow can be eliminated from private property.

6.5.6 Degree of Treatment Plant Expansion Required to Handle CSO Volumes

Metro's consultants are finding that if we expand the plants to handle the wet weather flow reaching the plants now, a relatively small incremental additional expansion would be required to handle release of CSO detained to reduce CSO to a frequency of one event per year on average.

6.5.7 Effect of CSO Policy Upon Municipal Growth

A concern about Metro accepting CSO into trunk sewers and possibly occupying capacity for growth has been raised by an area municipality. That municipality has no combined sewers, but does have foundation drains connected to the sanitary sewers. These drains contribute significant wet weather flow for treatment even though its sanitary sewers have no overflows. Our consultants have recommended that the plants be expanded to treat existing wet weather extraneous flow and they have recommended a small additional expansion to treat CSO.

Hence, during dry weather, about one-third of the trunk sewer is unused and available to convey flow released from detention facilities. If the flow to be released from detention facilities designed to limit CSO to one event per year on average is released at a rate equal to or less than the normal peak infiltration rate of 0.26 litres per second per hectare, the existing trunk system would have sufficient capacity for release of CSO.

However, with respect to the trunk sewers, conveyance of wet weather flow, if managed properly, will really be independent of the sanitary trunk sewer capacity required for population growth.

This is explained by the following points. The expanded flow monitoring program has shown that infiltration reduces to negligible amounts in dry weather. But the combined sewers are intended to carry normal peak wet weather inflow and infiltration on top of the peak dry weather flow rate.

If we look at a hydrograph of the flows in a typical trunk sewer over time we see that, on average, the trunks are typically only about two thirds full under peak dry weather flow on every three out of four days.

6.5.8 Example Calculation Relating Release of Detained Storage to Present Trunk Capacity

For example the Coxwell Trunk Sewer, near the confluence with the East and West Don Trunks, the Massey and the North Toronto Trunk, drains an area of 19,709 hectares. The Coxwell has capacity to convey peak infiltration of 0.26 L/s/ha. Since infiltration reduces to negligible amounts in dry weather which occurs on average three out of four days, the peak infiltration capacity of the Coxwell is available to convey a volume of detained flow released in this dry weather period. The total volume of detained flow that can be released without impinging on sanitary peak flow capacity is 996,000 cubic meters, based upon (0.26 L/s/ha. x 3600 x 24 x 3 x 19709 x 0.75 x 1/1000).

Consultants (reference) have identified that 242,330 m^3 needs to be detained in the combined areas leading to the Coxwell in order to limit CSO to one event per year. So if this detained flow is released at not more than the normal peak infiltration rate of 0.26 L/s/ha, it would take about 3/4 of a dry day to pass through the Coxwell Trunk Sewer.

Hence, detained volumes would not have to be held for the full three days in order not to exceed the normal 0.26 L/s/ha. capacity allowance, but for approximately 3/4 of a day in the Coxwell area. In addition, this detention volume would not be utilized on a daily basis but rather infrequently when significant wet weather occurs.

Today this unused capacity is conveying wet weather flow sometimes detained in basements! The basement environment is at least as important to the residents as the outside environment! Both basement flooding and CSO would be reduced under the proposed wet weather flow management policy.

6.5.9 Additional Perspective Upon Effects of Growth on CSO Policy

Significant growth is anticipated in the Don System area and we will be looking at providing for growth and at the same time looking at options of providing for CSO and wet weather flow.

We anticipate that economy of scale may favour a comprehensive solution to the capacity question and accelerate the solution to the CSO problem.

6.6 Implementation of CSO Policy

6.6.1 Addition Legislative Mandate Recently Enacted

Province of Ontario Bill 53, an Act to Amend the Municipality of Toronto Act, was proclaimed in December, 1989. This Act contains a clause which would permit Metro to share in the cost of detention facilities proposed by the Area Municipalities to manage wet weather flow to reduce basement flooding and to reduce CSO.

6.6.2 Time Frame and Cost Sharing Arrangements

If expenditures for sewer improvements continue at traditional levels, implementation of the proposed CSO measures will happen gradually over a period of approximately 20 years. Tasks ahead will include the area municipalities and Metro Toronto assigning

priority to projects and undertaking highest priority projects first. Input from the public and interested agencies through the environmental assessment process should assist in assigning priorities.

The formula for cost sharing provides for two ranges of CSO control - from 60 to 90 percent. and above 90 percent. Control to one event per year on average would fall generally within the higher range of control. Selection of the range of control would be by the proponent of the project and would take into account many factors including intended uses of the receiving water course or water body.

6.6.3 Relationship of CSO Policy to Other Water Quality Control Programs

Metro Works views the proposed policy as becoming a future component of the Province's proposed Remedial Action Plan for Metropolitan Toronto, which is currently being formulated.

It will also be impacted by MISA implementation. Before Metro's CSO Policy is recommended for adoption, Metro is seeking assurance from the Ministry of the Environment that regulations being contemplated for the Municipal Sector under the Municipal Strategy for Abatement (MISA) will reflect the nature of the CSO problem. If Metro accepts additional CSO for treatment future MISA regulations must not retroactively require full secondary treatment of CSO under storm conditions which exceed the selected design storm. Future MISA regulations must recognize hydrologic considerations in the setting of standards and criteria for the treatment of CSO. The Province should continue its practice of issuing draft MISA regulations for review and comment prior to their coming into force in order to develop a consensus that requirements are achievable practically and economically.

Watershed plans have also impacted CSO policies. The Ministry of the Environment has announced a proposed strategy to begin the Humber and now the Don River clean up. The reduction in untreated CSO is a component of these proposals.

6.7 Auditing and Updating of CSO Policy

This CSO Policy is not intended to stifle innovation. When new options are identified then the policy will be reviewed to address them. This policy is intended to support

continued improvement in water quality that in the past has resulted from such pollution control measures as secondary treatment and sewer separation.

This policy is intended to be reviewed and updated on a regular basis to reflect change, including improvements in technology, higher standards and rising public expectations.

Since this policy is proponent-driven there is no dictation of the best solution, how fast the solution should be implemented or where it should be implemented first. It is primarily an offer to participate and share in the cost of pollution control.

Some might suggest we wait and do absolutely nothing until we find the magic solution. Some suggest we do nothing unless we can afford the Rolls Royce solution. But our experience has been that improvements have to be undertaken step by step with an organized and coordinated approach. Improvements will be incremental. In this way progress will be made in pollution control.

6.8 Conclusions

Based upon the CSO policies developed in Metropolitan Toronto and elsewhere (St. Catharines), the following conclusions are made.

a) The development of pollution control strategies was not possible before the advent of computer modelling studies. Modelling has integrated vast data bases including flow measurement under dry and wet weather conditions, population by census and projection, land use, precipitation and water quality parameters.

b) Jurisdiction can be a dominating influence, and it is important to have cooperation in the planning process to accomplish an effective overall strategy for pollution control.

c) The approach to solutions has to be comprehensive. Solutions have to be prioritized for implementation over the long term in view of the cost. The cost per capita should be presented to the public through appropriate means to place the cost of environmental improvement in perspective.

d) Publication of outfall survey results and progress in cross connection control initiatives can raise public awareness of the pollution problem.

e) Use of financial incentives can overcome legal limitations. The proposed Metro Policy is a financial incentive with conditions to encourage area municipalities to design their pollution control facilities to be compatible with Metropolitan facilities. Consideration should be given to initiating financial incentives, user fees and/or regulations to address the private sources of excessive wet weather flow.

6.9 References

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CHAPTER 7

Pollution Control Planning for Combined Sewer Overflow Abatement and Wet Weather Flow Management St. Catharines Area Pollution Control Plan (SCAPCP)

Cindy M. Toth

ABSTRACT

The major watercourses and recreational beaches of the St. Catharines area experience chronic water quality violations due to excessive fecal coliform densities. SCAPCP is designed to identify pollution sources, assess their impacts and determine solutions.

An analysis of the extensive 1986/87/88 field data and computer modelling was used to assess the impacts of upstream inputs, dry weather seepage, direct industrial discharges, Water Pollution Control Plant (WPCP) effluents, stormwater runoff, CSOs, and WPCP bypasses upon receiving water quality. The major pollutant sources are predominantly due to wet weather. Thirty of the area's 91 CSOs are identified as critical. Stormwater discharges near beach areas also impact recreational water quality.

Proposed remedial actions include retention of critical CSOs, deep tunnel storage/conveyance, relief sewers and retention/treatment of lakefront stormwater discharges. Disconnection of roof downspouts and footing drains is proposed for specific combined sewer areas. To finalize the plan, technical solutions are being refined, the public consulted, and jurisdictional and funding implications are under consideration to develop a prioritized Implementation Plan for the Pollution Control Plan.

7.1 Study Area

The St. Catharines study area of about 52 km^2 includes the cities of St. Catharines and Thorold with a population total of approximately 140,000.

The populations of both cities have been stable with an average annual growth rate of 0.1% over the last few years. Presently, there is little area available for infilling in either city, although some redevelopment is occurring in St. Catharines and to, a lesser extent, in Thorold.

The land use characteristics for St. Catharines and Thorold (CH2M Hill, 1989) are:

	St. Catharines	Thorold
Residential	65% (22 km^2)	70% (13 km^2)
Commercial/Industrial	12 (4 km^2)	2 (0.5 km^2)
Industrial	10 (3 km^2)	5 (1.0 km^2)
Open Space	13 (4 km^2)	23 (4 km^2)
	(33 km^2)	(18.5 km^2)

7.1.1 Aquatic Systems

The St. Catharines area has a wide variety of aquatic systems (see Figure 1) which are key features of the natural environment and which provide recreational uses. Along the shores of Lake Ontario, beaches provide for swimming and other water sports such as fishing and sailing. In addition, there is a world class rowing course on Martindale Pond, linear parks along the Lake Ontario shoreline, and parks and trails along the area's waterways. Many of these systems are also used for shipping, for the drainage of urban and agricultural lands, for the generation of hydro- electric power and for industrial uses.

The area has three major riverine receiving waters, the Welland Ship Canal (WSC), Twelve Mile Creek (TMC) and the Old Welland Canal (OWC). The flows in these waterways are highly regulated with annual flow rates of 35, 190 and 3.4 cms for the WSC, TMC and OWC, respectively. These watercourses are, presently, the focus of heritage-sensitive tourist-development initiatives (MMM et al, 1989).

The Old Welland Canal in particular, has historic significance as one of the first manmade waterways from Lake Erie to Lake Ontario. Some sections date back to the first route which opened in 1829 (Trail Guide, 1988). Portions of it are presently buried within a box culvert. Several major paper mills are sited along the Old Welland Canal.

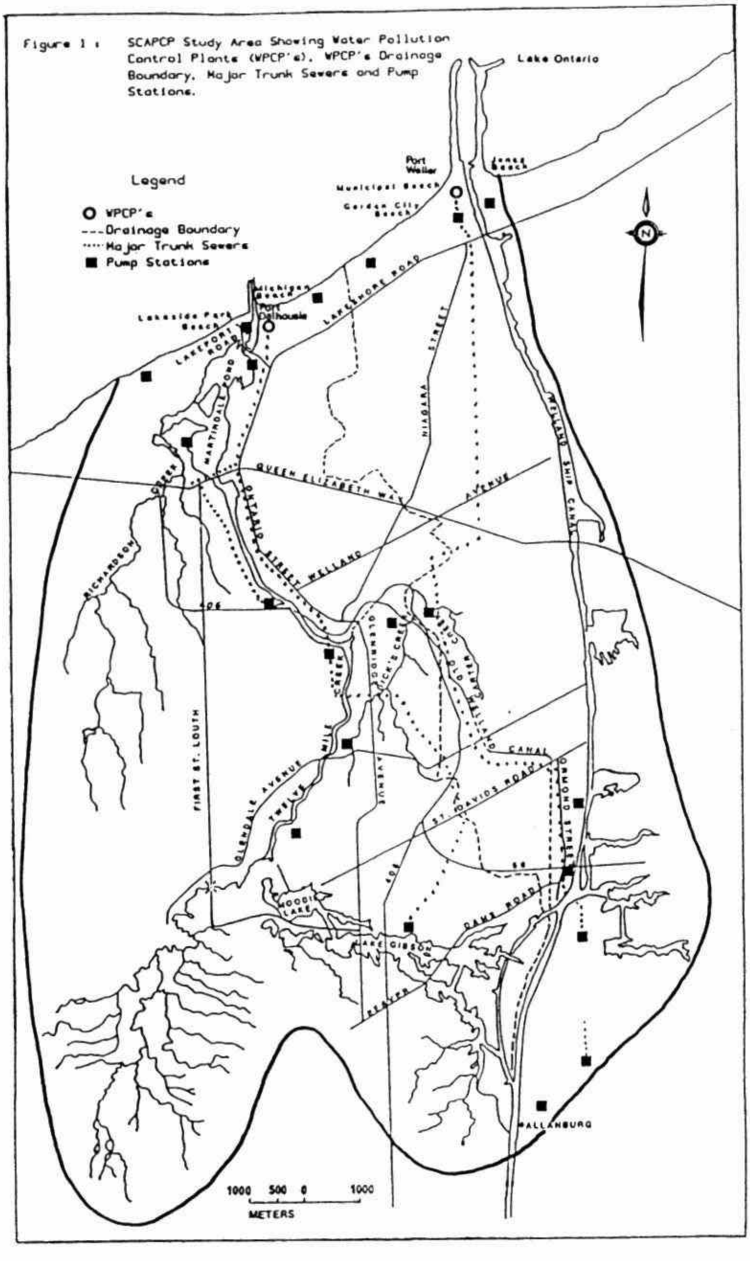


Figure 1: SCARCP Study Area Showing Water Pollution Control Plants (WPCP's), WPCP Drainage Boundary, Major Trunk Sewers and Pump Stations

Five recreational beaches exist along the shores of Lake Ontario: Jones Beach, Municipal Beach, Garden City Beach located near to the Welland Canal discharge, and Michigan Beach and Lakeside Park Beach located near the mouth of Twelve Mile Creek. In addition, two smaller watercourses, Walkers and Spring Gardens Creeks discharge directly to Lake Ontario in the vicinity of several of these beach areas. These recreational beaches and several of the watercourses experience chronic water quality problems due to excessive densities of fecal indicator bacteria.

7.1.2 Water Quality Issues

The major riverine systems of the study area are eutrophic, turbid, and suffer from the release of deleterious substances from the various municipal, industrial, agricultural activities and waste landfills located in their watersheds. The initial water quality of the Welland Canal is established by Lake Erie, but modified by municipal, industrial and ship discharges. The water quality of the old Welland Canal is similarly established, but is significantly modified as its waters are diverted through Lake Gibson into Twelve Mile Creek where the agricultural and urban areas add various pollutants. The actual degree of deterioration is described more fully below and completely documented in two reports (P&R, 1987; BEAK, 1990).

The major human uses and ecosystem features of the surface waters described above require that surface water quality be improved to provide for 4 identified features:

- swimming at the Lake Ontario beaches;
- aesthetics associated with the international Henley Regatta on Martindale Road;
- improvement of the warm water fishery; and
- reduction of eutrophication of the water.

Based upon the identified public concern with pollution and the association of the posting of beaches (effectively beach closures) with pollution in the minds of the public, the major emphasis of the St. Catharines Area Pollution Control Plan (SCAPCP) was achieving swimmable water at beaches. This required control of fecal coliforms (the parameter which defines the acceptability of an aquatic system for swimming) and suspended solids (a major parameter affecting aesthetics as measured by water clarity-turbidity).

7.1.3 Sewer System and Jurisdictional Responsibilities

The sanitary sewer systems of both St. Catharines and Thorold are integrated and drain north to two Water Pollution Control Plants (WPCP's). These two plants are situated near the shores of Lake Ontario. Port Dalhousie WPCP lies to the west and Port Weller WPCP to the east along the study area lakeshore (Figure 1). Presently, the plants are rated at 13.5 MIGD and 8.5 MIGD, respectively. Work has begun on both plants to upgrade the facilities, Port Dalhousie to 13.5 MIGD with peak capacity of 22 MIGD plus storm facilities of 5 MIGD, and Port Weller to 15 MIGD with peak capacity of 30 MIGD. Drainage areas for each plant are comparable in size and are about 24 and 28 km^2 for Port Dalhousie and Port Weller, respectively (P&R, 1981; CH2M Hill, 1989). There are 5 major trunk sewers, and 20 pumping stations within the study area (Figure 1).

The jurisdictional responsibilities for the sewerage system are split between the area municipalities of St. Catharines and Thorold, and the Regional Municipality of Niagara. The Region oversees the operation and maintenance of the WPCP's, the pumping stations, the trunk sewers and pipes with design capacities of greater than 6 cfs (170 L/s). The area municipalities are responsible for local sanitary and combined sewers with design capacities of less than 6 cfs (170 L/s).

Older areas are serviced by combined sanitary and storm sewers, while newer developments have separated systems. In 1974, the fully and partially combined areas comprised about 40 to 50% of the study land area.

Sewer separation programs have been undertaken for many years, usually associated with road works, local area improvement programs, basement flooding relief work and in conjunction with new development. A roof leader disconnection program was initiated in St. Catharines in the past but was not actively pursued. Presently, 16% of the study area remains combined and an additional 5% is partially separated.

Thorold is presently undertaking an intensive roof leader disconnection program based on a recent smoke testing study which identified problematic connections (Proctor & Redfern Group, 1987). Under the Provincial Offenses Act, the City of Thorold is issuing fines (for $103) to violators with illegal roof connections to sanitary or combined sewers in certain areas (Frank Lewis, City Engineer, Thorold, personal communication).

Periodic surcharge and basement flooding still occur in wet weather in certain areas. In the past, to remedy these hydraulic problems, relief sewers and overflow weirs were constructed. These overflows continue to contribute to the overall reduction in receiving water quality degradation.

Several key reports have assessed the area's services such as the Niagara Water & Sewer Service Review (Regional Niagara, 1981), Thorold's Report on the Sewerage Systems (Proctor & Redfern, 1970), and a number of studies on various areas within St. Catharines (Refer to Proctor & Redfern, 1985 for a synopsis of available reports). With the preparation of these reports most of the sewered areas within the Cities have been hydraulically modelled and/or analyzed to some degree.

7.1.4 Other Agency Responsibilities For Water Quantity and Quality Controls

Other agencies also have responsibilities within the St. Catharines area. The Niagara Peninsula Conservation Authority has the responsibility of flood protection and erosion control in watercourses.

The Ministry of the Environment has the regulatory responsibility for direct industrial and municipal effluent discharge quality, and maintaining the provincial water quality objectives.

The Niagara Regional Health Unit has the responsibility of ensuring safe and swimmable waters at the area's recreational beaches. These beaches have been permanently placarded by the Medical Officer of Health since the early 1980's.

The St. Lawrence Seaway Authority oversees the operation of the Welland Ship Canal and Old Welland Canal as part of the inland waterway. This involves managing navigational aspects and flow regulation through a series of lock systems on the WSC.

Ontario Hydro has the responsibility of flow regulation of TMC which is used in the upper end (via WSC diversion through the Lake Gibson and Lake Moodie systems) for hydro-electric power generation at DeCew Falls.

7.2 St. Catharines Area Pollution Control Plan (SCAPCP)

Field studies carried out by MOE during 1983 to 1985 indicated seriously degraded water quality in area watercourses and beach areas (Griffiths and Heathcote, 1986; MOE, 1986). This information, combined with the permanent placarding of area beaches stimulated the municipalities to initiate a pollution control planning study. The framework for the St. Catharines Area Pollution Control Plan was developed in late 1985 to early 1986 (P&R, 1985). It was followed by an agreement later in 1986 between the Cities of St. Catharines and Thorold, the Regional Municipality of Niagara and the Ministry of the Environment to jointly fund a pollution control planning study.

The study was to:

1. To identify and define existing water quality and sewer system problems in the study area. The SCAPCP study area includes all surface waters and the sewer systems of St. Catharines and Thorold (see Figure 1).

2. To develop and evaluate the effectiveness and costs of pollution control options, and resulting improvements in water quality; and finally,

3. To develop a comprehensive, area-wide preferred Pollution Control Plan with a series of cost-effective options and implementation recommendations.

The City of St. Catharines is the lead agency responsible for the day to day study co-ordination and administration. Study management is provided by a Joint Technical/Steering Committee which is responsible for overall project direction and financial control. Committee members represent the MOE (West Central Region, Water Resources Branch, Project Engineering Branch, and Laboratory Services Branch), the Cities of St. Catharines and Thorold, the Region of Niagara, the Niagara Regional Health Unit, and the Niagara Peninsula Conservation Authority. Periodic consultation also involves the MOE Environmental Assessment Branch.

The study is divided into three phases (Figure 2). The first phase was carried out in 1986 and 1987, and involved extensive field work to gather data on the existing watercourses and beaches. As well, several representative sewer system drainage areas including the 2 WPCP bypasses were monitored for quantity and quality. The major quality emphasis

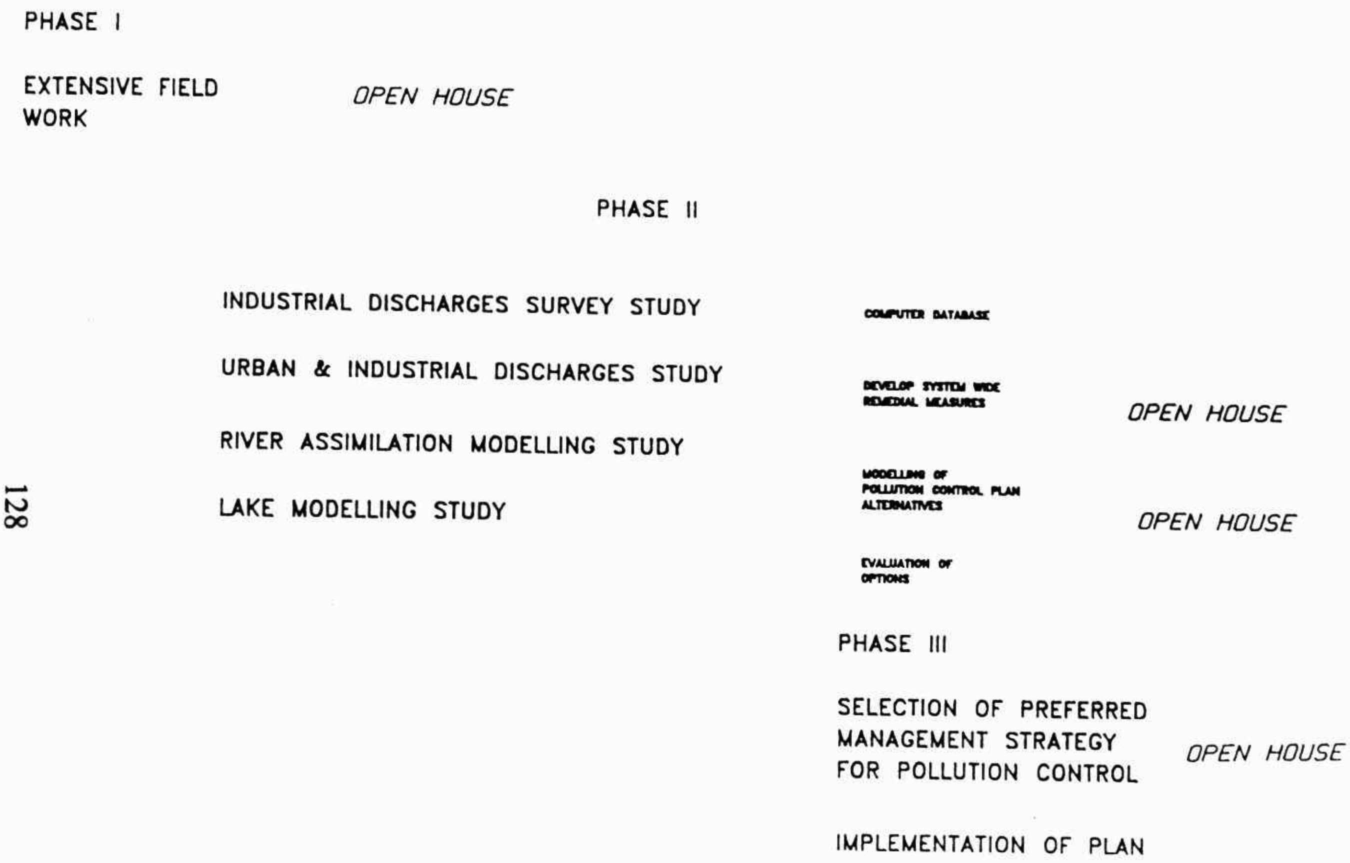


Figure 2: St. Catharines Area Pollution Control Plan - Phased Implementation

was placed on bacteria as an indicator of contamination by human wastes (fecal matter). Data were collected under both dry and wet weather conditions throughout the field collection period.

The second phase used the above data with a series of computer models to estimate pollutant loadings, to determine receiving water impacts, and to aid in the evaluation of various pollution control options. Problem areas were identified and prioritized in terms of bacterial loading impacts and sewer system hydraulics. These aspects were considered for both existing and future development conditions. Preliminary pollution control options were formulated and several system-wide schemes were proposed. Subsequent river assimilation and lake modelling have predicted the impact on receiving watercourses and beach water quality.

The third phase of SCAPCP involves the formulation of a comprehensive, area-wide Pollution Control Plan with recommendations for phased implementation and definition of jurisdictional responsibilities.

7.2.1 Dry Weather Sewer Outfall Survey

A dry weather outfall survey was carried out in 1986 and 1988. Information was gathered on dry weather pollution sources from over 70 sewer outfalls. Discharges were sampled from 45 outfalls and results were used to prioritize them based on bacterial densities. Other conventional parameters such as nutrients and metals were also analyzed. Priority outfalls were investigated for remedial action of which 10 identified problems have been corrected. Immediate benefits were realized from these efforts. Several major flows of sanitary sewage which were discharging to Twelve Mile, Tremont and Carter Creeks, and the Old Welland Canal were halted. Problems included CSO grate and weir blockage, and sanitary/storm sewer cross connections. There were over 20 additional outfalls which require a further investigation as a part of the continuing outfall abatement program.

7.2.2 Urban and Industrial Discharges Study

The potential sources of pollutant loadings were identified (CH2M Hill, 1989) as:

1. Flows from upstream of the study area,
2. Dry weather baseflow/seepage,
3. WPCP effluents,
4. Direct industrial discharges,
5. CSOs and WPCP bypasses, and
6. Stormwater.

Pollutant loadings and outfall discharges were defined using STORM, EXTRAN and SUDS computer models. Baseline volumetric and fecal coliform loadings assessments were used to determine the major impacting sources.

In terms of volumes of input to the receiving waters, the upstream flows dominate, while the other sources such as dry weather seepage, WPCP effluent, industrial discharge and wet weather flows are minor inputs (Figure 3). But these upstream flows are not a significant source of fecal coliform loadings (see Figure 4) since the fecal coliform density is quite low and is below the recreational guideline.

Wet weather sources, although small in volume over the summer, contribute the majority of the fecal coliform loadings to the receiving waters (Figure 4). CSOs and WPCP bypasses were identified as the major pollutant sources influencing the area's creek and beach water quality during wet weather. As well, the stormwater outfalls located in the vicinity of beach areas cause further degradation of recreational water quality during both wet weather and dry weather (see Figures 4 and 5, respectively). Upstream flows are the major source of fecal coliform loadings during dry weather (Figure 5), but are not significant from the overall perspective (Figure 3).

7.3 CSO Control Program

The proposed program to control CSOs is comprised of two approaches. The first approach directs works to reduce inflow on a sub-basin level. This approach deals more with sewer capacity and the removal of inflow points (foundation drains and roof leaders), and less with pollution control. The second approach deals with CSO control on a system-wide basis. This approach is geared towards the reduction of overflows to achieve various control levels (e.g., 11, 4 or 1 overflow per summer season).

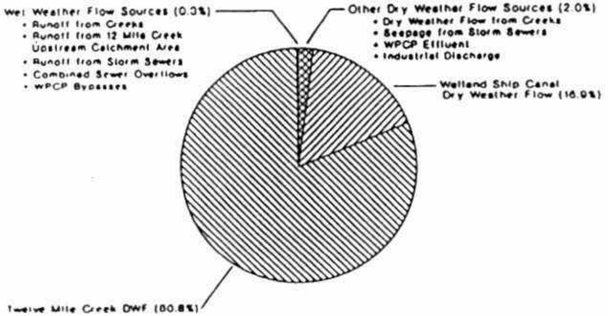


Figure 3: Volumes Entering the Receiving Waters During A Typical Summer Season

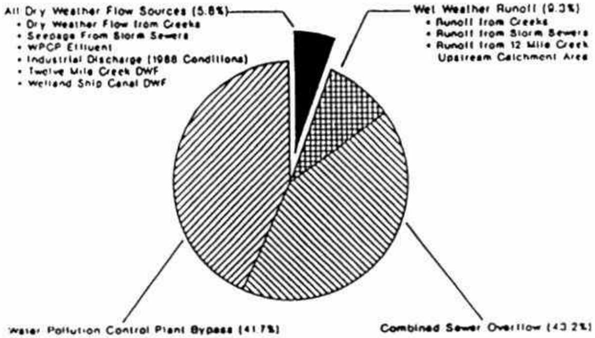
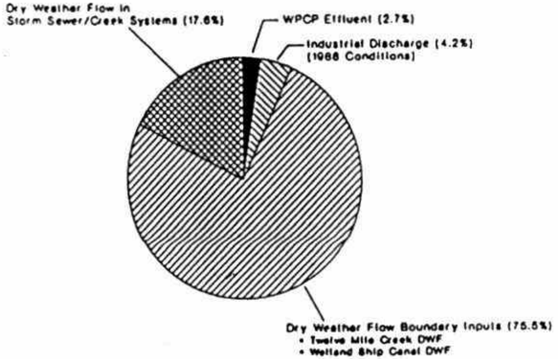


Figure 4: F.C. Loads Entering the Receiving Waters During A Typical Summer Season With 1988 Industrial Conditions



from: CH2M Hill Engineering, 1989

Figure 5: Dry Weather Fecal Coliform Loadings During A Typical Summer Season With 1988 Industrial Conditions

7.3.1 Sub-basin Control Program

Area wide inflow and sewer separation was assessed. The cost estimates range from $7 million for the disconnection of roof leaders to over $300 million for complete separation (roof, building footing, and road drain disconnection) for the entire study area. Predicted pollution control measured in terms of fecal coliform loading reductions range from 10% to 75%. Even with complete separation, several critical CSO discharge points still spill 13 to 15 times during the typical summer season. As well, separated stormwater still discharges in the vicinity of beach areas with subsequent impairment of recreational water quality. As a result it was considered more effective to carry out separation selectively with the objective of eliminating as much stormwater and inflow/infiltration to the combined sewers as possible in problem areas.

To achieve selective separation the study area was divided into 35 sub-basins based on sewershed boundaries. Each sub-basin area was reviewed with municipal staff to confirm critical overflow locations, hydraulic constraints, historical basement flooding and backup records, and the benefits expected with local improvements (i.e. pollution control benefits or hydraulic improvements). On this basis, a sub-basin works program was proposed at two levels of control:

1. Full control includes road, roof and foundation drain disconnection along with various infiltration/inflow reduction programs (e.g. minor sewer system modifications such as replacement or relining and weir adjustments).

2. Partial control excludes road drainage disconnection.

The estimated costs at this time are about $47 million for full sub-basin works, and $15 million for partial. These local controls would serve to:

- i) somewhat reduce the frequency of overflow events,
- ii) reduce inflow/infiltration,
- iii) improve local capacity,
- iv) reduce basement flooding or stormwater back-up, and
- v) improve linkage capacity to larger trunk sewers.

7.3.2 System Wide Control Program

The system wide control program used major works on the combined sewer system to control critical overflows and sewer surcharging problems not remediated by the sub-basin control program. Three levels of control were evaluated, based on the amount of overflow which would occur at an overflow location. These levels were 11, 4 and 1 overflow per summer season at any overflow. These levels of control were assessed in combination with both full and partial sub-basin control programs.

Thirty one critical overflow points have been identified as having less than 85% to 90% volumetric control. The control is related to the volume of overflow spilled at each CSO location. The ideal performance is zero overflow and 100% volumetric control. Twenty two CSOs presently discharge more than 10 times per typical summer. Considering area-wide, full separation (roof leader, foundation drain and road drainage separation), 6 overflow points remain critical. This supports the reasoning behind recommending sewer separation only on a site selective basis, in combination with more major works for pollution control.

Major works for the three levels of CSO control include 2 to 8 strategically located underground detention tanks throughout the area, relief sewers, a deep storage/conveyance tunnel and several specific weir adjustments. Critical CSOs would be controlled with storage and flows would be released back into the sewer system for treatment at a WPCP. Eighteen of the area's 31 critical overflows are located in proximity to the proposed tunnel. Preliminary cost estimates for the major works range from $11 million to $76 million depending on the level of control.

Three final scenarios were evaluated involving pollutant (bacteria) loading reduction for the three levels of CSO control combined with the partial sub-basin control program. The scenarios and results achieved are the following:

1. Partial sub-basin control program and the major works program with a target of 11 overflows per summer season: a fecal coliform loading reduction of 24% is predicted.

2. Partial sub-basin control program and the major works program with a target of 4 overflows per summer season: a fecal coliform loading reduction of 63% is predicted.

3. Partial sub-basin control program and the major works program with a target of 1 overflow per summer season: a fecal coliform loading reduction of 93% is predicted.

Costs for the three levels of control are $26 million, $52 million and $91 million, respectively.

7.4 Stormwater Control Program

Options for the control of the stormwater discharges in the vicinity of the 5 recreational beaches were investigated. These options include shoreline stormwater diversion with discharge to the Welland Ship Canal, and stormwater treatment facilities. This latter option consists of 4 flow equalization ponds along the lakeshore with either chlorination/ dechlorination or ultra violet radiation as treatment.

Shoreline stormwater discharge control levels were established at 11, 4 and 1 discharge event per summer season. In a sensitivity analysis using daily beach bacterial densities and the results of lake modelling, these targets were set with 11 discharge events to the lakeshore seen to correspond to about 70% of the swimming season with acceptable bacterial densities. Four events corresponds to about 90%. One discharge event per summer season was adopted as a target in light of current MOE, municipal and regional views. These percentages are preliminary and were used for initial target setting. These percentages relating to the proposed pollution control options are being further refined after integrating the river and lake modelling results.

Costs for stormwater control were estimated as follows.

1. Flow equalization ponds with chlorination/dechlorination. Capital costs range from $3 to $6 million. Annual operation and maintenance costs range from $13,000 to $27,000.

2. Flow equalization ponds with UV. Capital costs range from \$6 to \$12 million. Annual operation and maintenance costs range from \$42,000 to \$84,000.

3. Shoreline Diversion with disinfection. Capital costs range from \$4 to \$6 million.

These preliminary estimates do not include land costs, and feasibility study costs.

7.5 Other Controls

Other more minor, proposed controls were recommended.

1. Stoop and Scoop Program: Most municipalities conduct programs to control pet litter deposition. It was recommended that in the vicinity of beach areas and areas with watercourses which drain to the lakefront, an enhanced enforcement program be developed and implemented.

2. Dry Weather Seepage Abatement Program: It was recommended that such a program, discussed above in the "Dry Weather Sewer Outfall Survey" section, be continued with investigation and corrective action to abate dry weather pollutant loading sources.

3. Catchbasin Cleaning Program: Municipalities conduct catchbasin cleaning programs to ensure that obstructions and debris are cleared. The ongoing programs in the area municipalities were evaluated to determine if enhanced programs would result in further fecal coliform loading reductions. On this basis no changes were recommended to the existing levels of service.

4. Street Sweeping Program: Municipalities conduct street sweeping programs for dust and litter control. Again the ongoing programs were evaluated to determine if enhanced programs would be beneficial. It was concluded that this would not result in significant fecal coliform loading reductions at a reasonable cost.

7.6 Public Consultation

Throughout the three phases of this study, public consultation has played a key role in the pollution control planning process.

An open house was held in June 1987 to provide the public with information on SCAPCP's background, organization and preliminary field study results. In July 1989, with several consultants' studies near completion, another open house was held. SCAPCP information was provided, as well as, detail on proposed pollution control options. The comments were used to help determine the preferred options. A week-long public review session was held in December 1989. Again background SCAPCP information was presented, and displays of the revised, proposed pollution control options.

From the public, municipal and MOE comments received at these sessions, a preferred Pollution Control Plan was developed, followed by an open house to obtain further public comment.

7.7 Review and Decision-Making Process

The SCAPCP study began with a problem definition stage which provided the scope for the study, and established the study objectives. The major pollutant loading sources were identified and defined to lead into the development of a long list of options for pollution controls specific to these sources. Through a set procedure the long list of options was shortened. In the final evaluation, options were assessed in terms of their effectiveness in reducing water pollution in wet and dry weather, social and environmental impacts, operation and maintenance requirements, basement flooding reductions and costs. This assessment was completed first within the Urban and Industrial Discharges component of SCAPCP, to be followed by other discharge components.

Throughout the study, review and decision-making has followed a systematic and logical planning process which has been documented. Many reiterative steps have been required to incorporate comments from municipal, regional, and MOE representatives, and the public.

7.8 Conclusions

The following conclusions are drawn from this study.

1. Wet weather sources greatly dominate bacterial loadings. This results from the very high fecal coliform densities found in combined sewer overflows and WPCP bypasses. Stormwater discharges from lakefront outfalls and creeks are also contaminated, increasing the degradation of recreational water quality at area beaches.

2. It is clear that if bacterial problems are to be alleviated at the beaches, combined sewer overflows and WPCP bypasses require control. As well, some storm and creek wet weather discharge control is needed in the vicinity of the lakeshore.

3. A number of combined sewer overflow and stormwater control options have been developed. Selection of the final combination of preferred options will include some of those mentioned in this paper, and may include others which are still being developed.

4. SCAPCP is looking for the best solution to the problem. We will soon be approaching the stage where jurisdictional and funding implications require definition and commitment. These aspects will be incorporated into the final recommended plan.

5. It is likely that this Pollution Control Plan will outline a phased Implementation Plan based on a prioritized work schedule. The time frame for implementation is expected to extend over as many as 20 years or more.

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CHAPTER 8

Implications of Environmental Assessment For Installation of a Stormwater and CSO Storage Facility: Case History

Werner Wichmann

ABSTRACT

Toronto's Eastern Beaches enjoy great popularity; however, each year, to the annoyance of the public, the Beaches are closed to swimming some 25 days on average due to elevated fecal coliform densities. Two CSO and several stormwater outfalls discharging to the nearshore zone of the Beaches are primarily responsible for the problem.

Following extensive water quality measurement and modelling studies, a plan was developed in 1987 to construct two detention tanks to intercept CSO and stormwater flow and detain such flow until there is sufficient capacity at the Main Wastewater Treatment Plant to accept stored flow from the tanks.

The project underwent procedures under the Class Environmental Assessment, Schedule B despite grandfather provisions which exempted it from Schedule B provisions. The decision to follow the EA Act was made by the City, due to the social sensitivity of the project. This resulted in extensive consultations with various agencies and several stormy meetings with the public between February 1988 and January 1989. In addition, the Minister of the Environment was requested to bump-up the project to a full environmental project assessment.

The project schedule was significantly delayed due to two major causes. First, early advertising for public meetings did not clearly indicate that any member of the public had the right to request a change in the category for Environmental Review from a "Class" approach to an "Individual Project" Approach (hereafter called a "bump-up") with the associated more stringent review requirements. Secondly, due to additional public

meetings, "bump-up" requests resulted in a detailed audit of EA procedures used by the City of Toronto, and a critical review of study findings. Approval for the project was given in April 1989. Subsequent tendering and reconstruction led to project completion in May 1990.

The City has gained valuable experience in the Class EA process and will apply it in all future projects. Critical points include early public consultation, public notices which cover all aspects of the act, and preservation of technical information in unambiguous general knowledge terms. As well, it is clear that agency comments/approvals must be non-conditional, if water quality control projects are to be implemented in a reasonable time period.

8.1 Background

Toronto's Eastern Beaches, stretching 2.5 kilometres from the City's eastern limit to west of Woodbine Avenue, are very popular and with good reason; they offer a sandy shoreline, boating, wind surfing, swimming, a boardwalk for leisurely walking, a bicycle path, adjacent parkland with playgrounds, tennis courts, refreshment stands, and even a couple of restaurants. The Eastern Beaches are, no doubt, one of the most used and loved recreational areas in Toronto. Yet there is one major problem associated with these beaches. Each year during the summertime, signs go up at the Beaches advising people of "Polluted Water - Swim at Your Own Risk" an average of 25 days each year..

While, historically, there has always been the occasional posting of the Eastern Beaches advising people that the water was unsafe for swimming, the problem became very acute in 1983. In that year, the Medical Officer of Health initiated, onshore beach water sampling for the first time as opposed to boat sampling which generally occurred further offshore. The change in sampling protocol ensured that the testing protocol being followed by the City with respect to water depth, frequency of sampling, etc., was in accordance with recommendations established by the Province of Ontario. These new testing procedures clearly indicated that the water quality of the nearshore area of the City's beaches was frequently in violation of Provincial Guidelines for recreational water quality of 100 fecal coliform per 100 mL (MOE, 1984). This caused a dramatic increase in beach closings in the City of Toronto.

These beach closings received extensive coverage in the media, including newspapers, radio and television. To the general public, the beach closings contributed to a perception that the lake had become increasingly polluted and filthy, contaminated by bacteria, toxics and, generally, a serious health hazard. This common perception is illustrated by a conversation that I recently overheard between a mother and her 6 year old child while observing other children swim in the shallow waters at the Eastern Beaches:

Child: "Mommy, see those children are swimming".

Mother: "I see - they are crazy! They will be glowing in the dark".

At the time I overheard this conversation, the beach was not placarded for being unsafe. It had not rained for a number of days. The lake was calm. The water was remarkably clear, and looked rather inviting. Yet the woman I overheard would not trust these signs but rather believed what she was being told daily by the news media.

8.2 Studies of Causes and Solutions for Beach Postings

There are a total of 10 storm sewer outlets and 2 combined sewer outfalls discharging into the nearshore zone of the Eastern Beaches. It is clear that these outlets play a major role in the beach closings.

The Public Works Department, therefore, recommended to City Council, in 1984, the undertaking of an intensive field study programme in the Eastern Beaches with a view to develop a predictive nearshore lake model that would permit the City to determine the impact of discharges from its storm sewer outlets and combined sewers on the water quality of the Eastern Beaches.

Studies were carried out in 1984, 1985 and 1986 (Commission of Public Works 1985,1986, 1987) to determine the impact of these discharges and other diffuse sources on the water quality of the Eastern Beaches. A model was developed to predict improvements in water quality for different configurations (extensions and eliminations) of sewer outlets. The analysis and evaluation confirmed that effluent from the City's sewer system at the Eastern Beaches is a major bacteriological pollution source. By contrast, at the Western Beaches, the Inner Harbour, and the Island Beaches, other

sources, such as the Humber and Don Rivers and the sewage treatment plants, are the major bacteriological contributors. The predictive model for the Eastern Beaches also indicated that the elimination of the combined sewer overflows has a minimal effect on the beach water quality due to the bacteriological mass loading from the storm sewer system. Accordingly, it was concluded that, in order to have a noticeable impact on beach water quality, remedial measures and physical improvements must take into account the flow from the storm sewer system.

The predictive model was then used to establish the impact of various management options on the beach water quality. These included the extension of the sewer outfalls, a greater distance into the lake, and the construction of detention tanks which would permit temporarily stored run-off to be discharged either to the Main Wastewater Treatment Plant, or into the lake by pumping to an extended outfall. The model proved that the extension of the outfalls would not provide an effective solution to the problem. The outfalls could not be extended far enough into the lake (due to hydraulic considerations) to provide adequate dispersion of the fecal coliform loadings, considering the shore-line configuration and lake currents in existence in the Eastern Beaches which trapped discharges for a period of time. It was, therefore, concluded that the only effective solution to the water quality of the Eastern Beaches would be to consider the use of detention facilities.

8.3 Eastern Beaches - Detention Facilities

In early 1987, a pre-design study was initiated to evaluate alternative detention strategies. Four storage alternatives were investigated:

i) a single tank scheme,

ii) a 2 tank scheme ,

iii) a shallow super conduit along the entire stretch of the beaches, and

iv) a deep tunnel in rock.

Each of the options had a design capacity that would restrict overflows to a once per year occurrence during the recreational swimming season. The detained run-off in all instances was to be discharged into an existing interceptor sewer which would convey the run-off

to the Main Wastewater Treatment Plant. The evaluation of the four alternatives took into account location, environmental and structural considerations, construction scheduling, operational flexibility, cleaning and maintenance, and cost.

The estimated costs for these options, updated to 1989 dollars, are:

Single Tank -	$14,163,600
Two Tank -	$13,084,000
Super Conduit -	$11,429,000
Deep Tunnel -	$18,862,800

As a result of this evaluation, it was concluded that the two tank alternative was the most feasibly alternative. This alternative proposed the construction of a tank 2250 cubic metres in capacity in Beaches Park and a 16000 cubic metre tank at Scarborough Beach. It had the advantage of permitting construction to be undertaken in two phases, thus allowing the confirmation of predicted improvements of beach water quality prior to the construction of the second phase.

Recommendations were made to City Council to proceed with the detailed design of the proposed detention tank facility in Beaches Park as Phase I of the work, as required to mitigate the discharge of fecal coliform bacteria from the City's sewer system into the nearshore area of the Eastern Beaches. In May of 1987, City Council approved of the undertaking of the detailed design of this facility. Staff recommendations to proceed with the construction of this facility in 1988 were approved by City Council in late 1987. The estimated cost to construct the facility in 1988 was $3,975,000.00, of which the Provincial MOE agreed to contribute 50 percent.

The purpose of the Phase I tank is to intercept the discharge from one combined overflow outlet and four storm sewer outlets. These five existing outlets will be intercepted by a header system to be built in connection with the tank construction. The tank serves a drainage area of approximately 107 hectares. It is expected that, as a result of the construction of the first tank, the number of days of beach postings at Woodbine Beach will be reduced by two-thirds from the current level of 25 to 16 days.

The design of the tank calls for the detention of all storm run-off and CSOs up to the volume generated by a one year storm. The run-off exceeding the equivalent volume of a one year storm, statistically occurring once a year, will be discharged via the existing CSO outlet at Kenilworth Avenue, after receiving some primary treatment in the tank (minimum detention time of 30 minutes for the one year storm). The detained flow will be automatically released at limited rates (200 l/s) via the Lakefront Interceptor for treatment at the Main Wastewater Treatment Plant at Ashbridges Bay. At the request of the Metropolitan Toronto Works Department, the tank was fitted with a 350 mm forcemain extending some 400 metres out into the lake. This will allow Plant personnel to override the automatic discharge feature and detain the flow up to 36 hours in the tank in the case of operating distress at the STP. After that time, the tank will be emptied by pumping the contents into the lake via the forcemain, except for the lower 0.6 metres of the tank. Because of its sediment content, the lower 0.6 m will be discharged to the Lakefront Interceptor.

The tank structure is approximately 75 metres long, 13 metres wide, and 3.0 metres deep. It consists of two chambers and is equipped with a semi-automatic cleansing installation for flushing of the tank after each rain event. The cleansing water will be drained into the Lakefront Interceptor. The tank is located underground in Beaches Park; the area above has been resodded. Accordingly, it is expected that there will be little evidence from a grade elevation in Beaches Park that there is, indeed, an underground storm water detention facility in existence.

8.4 Class Environmental Assessment (EA)

The proposed detention facility was eligible to be "grandfathered" and not made subject to the Class Environmental Assessment requirements for Municipal Sewage and Water Projects, since it had reached the contract drawing stage prior to October 11, 1987 - the phase-in date for which projects are required to follow the Class E.A. Due to the sensitivity of the project, the Department of Works of the City of Toronto decided, however, to follow the requirements of the Class EA. According to the Assessment criteria of Class EA, this project was deemed to fall under Schedule B.

8.4.1 Public Involvement and Request for EA Bump-Up

A public meeting was held in **February 1987**, at the Balmy Beach Club to discuss with the community the problem of beach postings and the City's Beach Improvement Programme, including the proposal for detaining storm and combined sewer overflow in tanks. The audience of the day showed great concern about the quality of the lake water and urged us to get on with the job of improving water quality. No concern was voiced at that time about the concept of detention tanks.

Then pursuant to the Department's decision to follow the Class E.A. Schedule B procedures, notices were placed in the daily press one year later on February 8, 1988 to advise the public of the proposed undertaking. The advertisement indicated that pertinent reports and drawings could be reviewed in the Department's offices during business hours.

Five members of the public viewed the documents during the thirty (30) day notification period. By March 3, 1988, a letter was received from the Kew Beach Residents' Association. As a result of the concerns expressed by the Residents' Association, a public meeting was arranged for April 7, 1988. Well over one hundred people attended. The majority of the people who spoke at the meeting were opposed to the project. The two main objectives raised were the following:

1. The project should be moved to another location to avoid:

   - disruption to community during construction
   - expected adverse effect on the parkland
   - expected odour problem from the facility.

2. The project is not an adequate solution to the water quality problem at the Beaches because:

   - there is no conclusive evidence that the source of the problem is the sewer outflows but rather that a significant source of contamination may originate from the Main Wastewater Treatment Plant.

   - the facility still allows for once-a-year overflow.

- the release of storm runoff to the Main WWTP cannot be guaranteed, hence the treatment plant should first be enlarged.

No consensus was reached at the first meeting -- it was agreed, however, that the Department would provide further information and investigate and report on other alternatives.

A second meeting was held on May 5, 1988 and additional information, including a report on possible alternatives, were presented. Again, the meeting was very well attended (well over one hundred attendees). Again, no consensus could be reached. The majority of the people who spoke objected to the project. It is interesting to note, however, that, after the formal part of the meeting, when small groups formed to discuss the project, a number of individuals came forward to support the project. Yet the supporters, in general, would not stand up at the meeting and voice their opinion.

At the time of the second meeting, no bump-up request had been received and the 30 day period had actually expired. However, the Environmental Assessment Branch of the Ministry of the Environment advised us that our Public Notice in the press did not meet procedural requirements. The public notice did not clearly indicate that objectors to the proposed project, had the right, by a certain date, to request the Minister to bump-up the project to an Individual Environmental Assessment, in the event that consensus could not be reached thereon. The Ministry was of the opinion that a further meeting was necessary.

It had been the Department's plan to construct the facility during the winter months, commencing construction in September, 1988. This required tendering the undertaking in May 1988. The request for a further meeting, therefore, resulted in the project being delayed from 1988 to 1989.

The next meeting was held on January 11, 1989. Previous objectors were notified that they had a 15 day period after the meeting, during which time a request for bump-up to an Individual Assessment could be made to the Minister. The Minister subsequently received 8 bump-up requests.

8.4.2 EA Review by Environmental Assessment Advisory Committee

The Minister asked the Environmental Assessment Advisory Committee (E.A.A.C.) to conduct a Defined (Category B) Review, which includes public consultation with groups and individuals directly affected by the proposal and to provide advice by March 6, 1989. The Committee sent out a request for submissions and a public meeting notice. The public meeting was held on February 27, 1989 and was attended by about 100 individuals. Numerous submissions were received by the E.A.A.C. including 6 written submissions, of which one was from the City of Toronto.

The submissions have been summarized by the E.A.A.C. under the following headings:

- Source of problem,
- Integration of planning processes,
- Capacity of Main WWTP to handle the detention tank release,
- Adequacy of the technology,
- Adequacy of assessment of alternatives,
- Impact of the detention tank, and
- Public consultation process.

With regard to the **source** of the problem, the objectors submitted that there is no conclusive evidence that the source of the problem is the sewer system and that a significant source may be the Main WWTP while the City defended their case by referring to the extensive studies in this regard. Some objectors submitted that, in light of the controversy about the project, both tanks proposed should be integrated with an expansion of the Main WWTP and the Remedial Action Plan for the Metropolitan Toronto Waterfront. The City noted the two phase approach allows assessment of Phase I before investing in Phase II.

Some objectors submitted that the Main WWTP would not have sufficient capacity to treat the flow from the tank. The Metropolitan Works Department responded by giving their full support for the project noting that the forcemain is only required for maintaining options in case of an upset at the plant.

The adequacy of the technology proposed and the adequacy of assessment of alternatives were also questioned. The objections stated that the proposal is untested technology,

should be viewed as a primary sewage treatment plant, and, as such, has no place in a densely populated residential neighbourhood. The City again referred to the extensive studies of alternatives undertaken and the fact that such facilities are operating successfully in many other places.

Several residents in the neighbourhood expressed concern about disruption during construction and possible odours from the tank vents. The City outlined its construction control programme and committed to installing an air filtering system on the vent.

Finally, there were complaints that the public consultation process in the early stages of the project was insufficient. However, the fact that the meeting with E.A.A.C. was, in effect, the fifth public meeting at which the project was discussed with the public, spoke for itself.

The E.A.A.C. reviewed the submissions and, on March 6, 1989, recommended to the Minister that:

1. Phase I of the proposed Eastern Beaches storm water detention facility not be bumped up.

2. The City establish a construction liaison committee with representatives from area residents and the City's Department of Public Works.

3. Phase II of the detention facility be subject to Class E.A., Schedule C.

After considering the submissions, the E.A.A.C. reached its decision in light of three criteria:

- Environmental significance of the project,
- Urgency and effects of delay, and
- Adequacy of the Class E.A. process and public involvement.

With regard to environmental significance, the E.A.A.C. concluded that adverse environmental impacts, e.g. disruption to park, would be modest, while environmental improvements, e.g. reduction in beach closings, would be significant. The Committee acknowledged that a bump-up would result in a serious delay and that the City had made

serious attempts to minimize any adverse effects. An improvement in water quality at the Beaches was of considerable benefit and a delay could not be justified.

With regard to the adequacy of the public consultations, the E.A.A.C. commended the City for going through the Class E.A., Schedule B procedures, even though the project was eligible to be grandfathered. However, the E.A.A.C. criticized the City's communication with the public, noting that it could have been improved. Specifically, documentation and information presented to the public was, in E.A.A.C.'s opinion, **too technical** and not easily understood by the public.

E.A.A.C. believes that some misunderstandings between the public and the City could have been avoided by making clear and responsive documents. Notwithstanding these shortcomings, E.A.A.C. concluded that the public consultation process was adequate, but recommended that the City follow Class E.A., Schedule C for the Phase II project.

The Honourable Minister of the Environment James Bradley adopted the recommendations of the E.A.A.C. and consequently the bump-up requests were refused.

Subsequently, the Department reported to City Council on the decision by the Minister and Council gave confirmation to proceed with the project in early May, 1989.

8.4.3 Further Perspective on EA Process

It should be noted that, parallel to the public consultation process, the Department had notified, pursuant to the Class E.A. requirements, a total of 11 different agencies and submitted a total of 10 applications for permits which are required under various statutes and from various agencies. These include:

- Approval under the Water Resources Act,
- Approval under the Metropolitan Toronto Act,
- Air approval under Section 8 of the Environmental Protection Act for the tank vent stack,
- Approval under the Lakes and Rivers Improvement Act, and
- Approval by the Coast Guard.

These consultations with various agencies, including other City Departments, and the approval process resulted in a number of conditions being imposed on the City, such as the Parks and Recreation Department requesting the installation of a lawn sprinkler system over the tank because of the shallow cover, and the M.O.E. requesting the City to implement a monitoring programme upon the completion and taking over operation of the tank. The objectives of monitoring were to determine the typical effluent quality and to measure the volume discharged to the lake and the Main WWTP.

The process of obtaining the numerous approvals was tedious and time consuming. For an applicant such as the City of Toronto, it is particularly frustrating if Agency A stipulates that approval will only be granted on the condition that approval from Agency B has been obtained.

If this approvals trend proliferates, applicants will soon find themselves in a vicious circle where each agency is requesting approval from some other agency(cies) first. This will create a deadlock which may make implementation of stormwater quality control too difficult.

In May, 1989, the City proceeded to tender the construction contract for the Phase I tank. By mid-July, 1989, the Department had secured all necessary approvals and the contract was awarded at a total contract price of $3,900,000.00. Construction commenced in early September was completed in May, 1990.

In order to comply with the E.A.A.C. recommendation to establish a construction liaison committee with public representation, the City south nominations to the committee by inviting the immediate neighbourhood and other individuals previously interested in the project to an on-site meeting. Only 3 residents attended -- an indication that, with the approval of the project, the interest, even of the most adamant objector, had eased.

8.5 Conclusions

In the case of the Class E.A. for the Eastern Beaches Detention Tank, Phase I, the process of public consultation, did not lead to consensus between the proponent and the intervenors. This resulted in several bump-up requests to the Minister and in a delay of the project by one year. The assessment of this case by the E.A.A.C. was speedy, thorough, and efficient, and lead to the bump-up requests being rejected.

The City has gained valuable experience in the Class E.A. process and draws the following conclusions:

1. Public consultation should commence as early as possible. Ample time for this procedure must be allocated.

2. Public meetings do not always achieve broad public consultation because a few intervenors may dominate the audience. Therefore, the City will, for future Class E.A. projects, consider several alternative means of public consultation, including an information storefront.

3. Information provided to the public must be in a simple, non-technical format but, at the same time, thorough and complete. Public relation techniques and assistance will be investigated by the City to support engineers in their endeavours to "get the message across".

4. Notifications and submissions for permits to public agencies are tedious and time consuming. The City appeals to approval agencies and their officers to abstain from making approvals conditional upon approval by other agencies.

8.6 References

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CHAPTER 9

Components Necessary for a Successful Nonpoint Source Control Program

Earl Shaver

ABSTRACT

This paper discusses the components that are necessary for a successful stormwater management program. The components are each necessary if a coherent strategy is to be developed and public support garnered. They include the following elements:

1. Problem assessment and magnitude - urban vs. agriculture, water quantity vs. water quality, nutrients vs. toxics.

2. Implementation strategy - on-site vs. off-site, retrofit vs. new construction, watershed vs. area wide.

3. Literature review and information transfer - have others been confronted with the same problem and is the information transferrable.

4. Selection of a design model - water quantity vs. water quality, continuous vs. event, peak vs. hydrograph, ease of application and extent of use.

5. Cost estimation and funding sources - general funding and consideration of permit fees, impact fees and utilities.

6. Monitoring for background data and expected practice performance - quantification of the problem and the level of control that can be expected from the individual practices.

7. Bylaw, regulatory framework, and design manuals - if the design community is to have regulatory requirements placed upon them, those requirements and how to comply with those requirements must be clearly stated.

8. Education, training, and publicity - this is the most important element of program implementation and must be directed towards all impacted parties including the general public.

9. Process to measure environmental response - once a program is initiated, there must be a means to measure the effectiveness of that program. This effort must go beyond simple water quantity/quality monitoring so that the average person can relate to and support the effort.

The discussion of these elements is based on experiences in the States of Maryland and Delaware, and work accomplished for the Auckland Regional Authority in New Zealand.

9.1 Introduction

This discussion is based on my experience in the development and implementation of a state-wide stormwater management program in Maryland, the development of program recommendations in the State of Delaware, and, at the request of the Auckland Regional Authority in New Zealand, an assessment of needs and direction to those individuals. Based on these experiences, a number of program components may be considered generic and will be documented here.

This assessment will provide recommendations and information on the following items:

1) Problem assessment and magnitude
2) Design considerations
3) Implementation strategy
4) Common and unique problem identification
5) Selection of a design model
6) Cost estimating and funding sources
7) Monitoring for background data and expected practice performance
8) Bylaw, regulatory framework, and design manuals
9) Education, training and publicity
10) Process to measure environmental response
11) The role of wetlands
12) Conclusion

9.2 Problem Assessment

Most regions of the United States are experiencing rapid growth at this time and a review of water quality data generated through the Nationwide Urban Runoff Program (NURP, U.S. EPA, 1983)) in conjunction with specific studies conducted in Maryland, Delaware, and New Zealand clearly indicates that water quality impacts are occurring. The urbanization that is occurring in this country, and its estuaries in particular, is a common problem in the character and variety of pollutants that are present in the storm runoff. Those pollutants include numerous metals, inorganic and organic compounds, as well as petroleum products. Toxicants commonly found include oil, grease, chlorides, and metals such as lead, zinc, bromium, arsenic, silver, cadmium, iron and copper. Most of these pollutants enter the waterways from road surfaces and are derived from rust, lubrication, tire wear, and engine exhaust. In addition, most of these substances are inert by nature and readily attach to sediment particles. Because of this attachment, the need to limit the movement of sediment into the estuaries is important if their water quality is to be maintained.

Agricultural pollution is a serious problem due to the nutrients that are applied to the cropland, the toxics that are present in pesticides, and animal waste disposal. In Maryland and Delaware one major water quality problem of the bay areas is over-enrichment resulting from agricultural activities.

Most people believe that conveyance of stormwater to the tidal limits will allow those pollutants transported by the stormwater to be carried out to sea. That assumption is generally not correct. Most estuaries are very poorly flushed and the pollutants that enter them will accumulate, and continued environmental degradation can be expected. Estuaries can essentially be considered as sinks where pollutants discharged into them tend to remain. This can be demonstrated easily in the situations being experienced in the Chesapeake Bay, the Delaware Inland Bays, and the Waitemata and Manakau Harbours in Auckland where pollutants have accumulated to such an extent that the productivity of the estuaries are being threatened. People need to understand that there is no such thing as away. Waste oil, toxics, sediment, and nutrients placed in streams are only transferred to another location in the water network, and there will be impacts.

Historically, the major impetus for stormwater control has been flood damage resulting from improper use of floodplain lands for developmental purposes and increasing

discharges due to the conversion of land to more impervious surfaces. Stormwater and flood control structures were originally implemented to reduce the level of downstream flooding and protect existing land uses. Stormwater management for flood control purposes must be considered in conjunction with wise land use decisions regarding tidal and nontidal floodplain land uses. Existing floodplain land must be preserved through a regulatory program so that existing problems are not exacerbated. In addition, the cost of protection of floodplain properties may exceed the value of the properties being protected. In those situations an acquisition program can be an important component of a flood control program to ensure that floodplain land is preserved. A stormwater program whose main emphasis is flood control and flood protection must be implemented on a watershed basis. Rather than require that each developer control the release of stormwater for large storms to a predetermined release rate, sites should be selected based on a watershed analysis that optimize control benefits. Too many random flood controls on a single watershed may increase downstream flood levels due to inappropriate placement of these structures. Water quality protection is most appropriately addressed on small watersheds or on individual sites while water quantity protection is most appropriately located on a regional watershed basis.

It must be understood that fisheries protection can only be provided on a limited basis by the application of stormwater management. Habitat protection is to a very large extent determined by land use. If the protection of cold water fisheries is a priority,consideration of developmental patterns must be a program component. Environmental protection can only be attained through a holistic approach to man and the environment. Technology alone will not provide environmental protection as there must exist a natural harmony for all system components to function as a unit. Too often a governmental agency will throw words at a problem and provide a false sense of well-being. A stormwater management program whose main purpose is to provide environmental protection is no small undertaking. Initial program implementation tends to simplify the problem. Recognizing the magnitude of program components at the initial stages of program implementation will provide program direction.

9.3 Design Considerations

Data can be developed, or is already available, that would provide a statistical record of rainfall events that occur on an annual basis. A water quality program could be developed

that recognizes rainfall depths, durations, and seasonal distribution. Designing a water quality strategy to treat a percentage of the annual storm runoff will provide a significant water quality benefit. Consideration of depression storage (puddles), in conjunction with open space requirements can reduce the amount of storage needed to a lesser amount. Based on situations in Maryland and Delaware, the initial runoff from all contributing impervious areas should be treated for water quality enhancement. It must be recognized that providing water quality protection for only a percentage of the rainfall events will still mean that some portion of the annual runoff will be released uncontrolled. That tradeoff is necessary due to the extremely large volumes of runoff that are associated with larger storms. Practices such as off-line storage can still provide significant water quality benefits by interception of the first dirty flush and allowing the excess runoff to bypass the initial flush control structure. A weir structure in the main channel can divert the initial runoff into the water quality practice while the larger flows overtop the weir structure and continue downstream. It must be understood that development and man's activities will cause adverse impacts. Stormwater management attempts to mitigate, to some extent, those impacts but a 100% level of protection cannot be obtained. Implementation of control requirements on new developments, in addition to retrofitting existing uncontrolled developments, can maintain a water quality balance.

As water quality protection is a major component of the overall stormwater protection strategy, detention time for the release of the first percentage of runoff should be at least 24 hours. It is also recommended that dead storage by means of a permanent pool be provided to enhance pollutant removal effectiveness. The permanent pool should have at least 25% of its surface area and less than 1 m in depth to promote the establishment of wetlands vegetation. Standards for the type of wetlands plants that should be established can be easily developed locally. Primary characteristics of those plants should be length of growing season and local suitability.

From a water quantity perspective, multiple storm control would provide the greatest benefit for downstream protection when used on a regional basis. The 2 and 10 year frequency storms are examples of storms that could be controlled to pre-development levels as a general guide unless a specific condition would necessitate a greater level of control. Any time that water quantity control is required, the downstream effects of hydrologic timing modification must be considered. This analysis of timing should be carried downstream to the next control point, which may be a road/stream crossing or the confluence of a larger stream tributary.

The use of infiltration practices must be carefully considered due to the susceptibility of these practices to clogging. If stream habitat protection is a major program component, infiltration must be considered if porous soils are prevalent in the watershed. Increased impervious land would reduce natural infiltration and lower groundwater tables which may convert a perennial stream into an intermittent one, thus destroying any hope of aquatic diversity. Infiltration cannot be used anywhere. The successful implementation of the site depends upon its area, depth to groundwater, and depth to bedrock. Maintenance of these practices is extremely important and can be difficult once clogging has occurred.

Ancillary programs to protect floodplain areas, existing wetlands, and maintenance of open space will provide water quality benefits in addition to their primary justifications. These areas provide water quality benefits due to their buffering capability for suspended solids.

The existing situation with respect to sediment control also needs to be evaluated and improved on a national basis. Most existing criteria needs to be updated with more types of control practices included, and the practices need to provide a reasonable level of site control. A clear distinction needs to be made with respect to the types of practices that are appropriate for dispersed flow and the types of practices that are appropriate for concentrated flow. The concentrated flow practices need to be sized more appropriately for the character of the soils that are prevalent to the local vicinity. Existing criteria in the States of Maryland and Delaware require 1800 cubic feet of storage per acre of land draining to the control structure (i.e. control of 0.5 in or 1.3 cm of runoff). Both states are changing that criteria to 3600 cubic feet (i.e., 1 inch or 2.5 cm of runoff) per acre (0.4 ha) to improve the efficiency of sediment removal.

Another aspect of local sediment control programs that needs to be re-evaluated is the size determination for when a sediment control plan needs to be submitted. Most existing criteria tends to be too large, and many projects have no regulatory requirements placed on them. In addition to the regulatory control, there is a serious need for additional sediment control inspectors. In my work in Maryland and Delaware it was realized that one inspector can visit approximately three large sites per day, and that his frequency of inspection of active construction sites should be at least once in a two week period. There is an existing growing problem with respect to sediment control that must be addressed in an aggressive manner to reduce downstream impacts. One benefit of reducing the exemption area even with inadequate staff, is that the process allows an enforcement mechanism when complaints are received.

9.4 Implementation Strategy

There are a number of steps that need to be considered for the development and implementation of an effective urban stormwater management program. The first and foremost need is to increase public support for the program through an educational effort. This effort must be developed and continued as a permanent function if public support is to be galvanized and maintained. This aspect of program implementation will be discussed later in this assessment. Also necessary as a public educational component would be the construction of typical water quality enhancement practices as demonstration projects. People could then physically see what this program encompasses and the benefits that can be gained through program implementation.

With the recognition that water quality conditions cannot be improved overnight, the stormwater program should not be implemented in a crisis mode. The first step should be to prevent the further decline of the region's water resources. This would necessitate the implementation of stormwater quality control on new residential, commercial, industrial, and institutional projects. This can be accomplished by a two tier approach that will depend on the size of the project and its drainage area.

- Projects of larger magnitude will be required to provide water quantity/quality protection with water quantity being subject to a waiver if watershed location would indicate that quantity control as being counterproductive. A fee structure should be established that provides a system for payment of a waiver fee. That fee would be based on the cost that would be incurred if on-site peak control was required. Certain projects may be suitable for both a water quantity/quality waiver and a fee structure should also be established for both.

- Projects of a smaller size should be considered only for water quality requirements on a case by case basis. The same fee structure as developed for larger projects (including the water quantity waiver) can also be provided for these smaller projects.

- Funds collected under the waiver fees can be used to provide regional water quantity/quality control based on watershed studies, also accomplished using the waiver fees. Regardless of the waiver fees, a permit fee should be required to offset the cost of plan review and inspection and enforcement.

An option to states or regional authorities providing full program implementation, is to hold meetings with local governments to determine the interest of the local governments in providing program implementation. This could be accomplished through a form of delegation of authority by the states or regional authorities with subsequent overview and periodic evaluation of program performance to determine whether delegation should be continued. The main burden for program implementation should probably still rest with the states or regional authorities but some local governments may want to maintain a local presence. Stringent guidelines should be established for this delegation of authority and those guidelines should include such items as legal authority, manpower, administrative procedures, and a review of field implementation.

As the program requirement for new development activities is established and implementation proceeds, a second phase of the overall program should be pursued. A prioritization of impacted watersheds should be initiated and a stormwater retrofit program implemented. Based on a watershed approach, sites could be acquired that would be retrofitted with a water quantity/quality practice that would improve the overall conditions of the specific watershed. There are a number of possible funding mechanisms that are available to implement such a program such as impact and user fees, and those alternatives will have to be investigated.

Sediment control is an area that will also have to evolve over the next several years. The first step should be the assessment of existing standards and specifications. In addition to the personnel needs and disturbed area considerations, site visit and enforcement procedures need to be developed and clearly stated. Sediment control is difficult to monitor and there is little incentive for the land developer to implement and maintain the needed practices. Enforcement penalties and options must be available for the situation where site compliance is difficult to obtain. Those options should include the ability to stop construction, possible civil fines, possible criminal penalties, and other options as the need arises. Fines collected should be used to fund needed areas within the overall stormwater program.

To assist contractor efforts to implement these required practices, educational programs should be developed having required contractor attendance (one person at least from each contractor) so that the importance of the practices can be stressed and implementation improved. Other educational programs need to be developed for the engineering design community and those individuals involved in the plan review process.

One process that may be helpful is a service that the State of Delaware provides to proposed land developers that is called DAS (Developers Assistance Service). One day per month all regulatory agencies have representatives assembled to meet with land developers regarding proposed projects. At that time developers are presented with a list of requirements that they then must address to obtain the necessary building approvals. This process takes place during the conceptual design phase and is extremely popular with land developers as they are aware of regulatory requirements at design outset.

Of primary importance, any requirements must be consistently implemented to all land developers to avoid any inference that one individual or entity is being unfairly treated. This program and the associated practices will cost money. The costs, when incurred by land developers, will be transferred to the consumer or property purchaser. If all developers have the same relative costs for stormwater control, there would be no economic advantage for any one developer, and the criticism regarding program implementation would be significantly reduced.

9.5 Common and Unique Problem Identification

There are a number of problems that appear fairly common in certain regions in the United States and to the Auckland region. Probably the most important area of commonality is the character of the stormwater runoff from urbanizing areas. The types of pollutants found in the Auckland runoff are very similar to the types of pollutants contained in urban runoff in U.S. cities. The only major differences are with respect to the magnitude of the problem.

Another area of commonality is with respect to the project approval process. In most urban areas in the U.S., projects must receive prior approval before the initiation of construction. For this reason the approach to stormwater management and sediment control can be similar. These programs have a much greater potential for success if the site planning is accomplished at an early stage and possible adverse water quality impacts are addressed either through on- or off-site requirements. Also, the use of design documents can greatly assist the design community and the general public in understanding the types of control practices that are needed, and accepted by the approval authority, in addressing the stormwater issue.

Another common area is the need for public and political education as an important component of program implementation. My experience in this field has shown the value of public and political support. The situations are similar in the types of educational activities that are available and most estuarine areas provide a rallying point for promoting the water quality benefits and the need for environmental protection.

In the U.S., federal law really specifies the minimum content of any issue that must be regulated, and the States may exceed those federal requirements as the local need arises. Thus you have certain areas of the country that address various environmental needs through more aggressive programs such as the Puget Sound restoration effort and the Chesapeake Bay program. Unfortunately, the problems tend to have to reach crisis proportion before these efforts seem to really become aggressive.

Another major difference is with respect to soils and geology. The predominant soils, slopes, and geology of various areas determine the types of BMPs (Best Management Practices) that are feasible as management tools. Practices that rely on infiltrating surface runoff into the subgrade will not be practical to pursue on clay type soils due to the tight nature of those soils and their high shrink/swell potential. New Zealand and certain areas of the U.S. are very young geologically and do not have the variety of soil conditions that exist in other areas of the U.S. The major management practices in areas of tight soils will be ponds and maximization of open space through land use decisions. The clay nature of the soils also creates additional problems with respect to settling of particulates when the clay soil gets into suspension. To get reasonable sedimentation, ponds may have to be larger in some regions than in others, and a greater use of wetlands vegetation would assist in that sedimentation process through flow retardance.

9.6 Selection of a Design Model

The issue of what hydrologic model to use, and the basis for a design manual are key elements of program implementation. The most common design procedure in use by consulting engineers is the rational formula. That is a peak flow estimation technique that has severe limitations when used for stormwater design purposes. Those limitations include an inability to consider watershed timing in the analysis of downstream flooding impacts resulting from the construction of stormwater management basins in a given watershed. There are other numerous problems with the rational formula, such as the

inability to generate a hydrograph and inaccuracies of the composite land use factors. A major advantage of the rational formula is its use where enclosed systems are encountered.

What is needed is a hydrologic model that provides relatively accurate results with a minimum of data inputs. It must also provide for the generation of the full range of discharges over the whole storm duration and compute a hydrograph to determine the volume of the runoff and its timing. As this model is being used to consider the changes in runoff characteristics from a before and after development perspective to assess the impact of the land use change, it does not have to predict with 100% accuracy what the runoff characteristics are. The important product of these analyses is to predict the relative change in the runoff characteristics. The model selected should have the following characteristics.

1) The model should be relatively easy to use.

2) The model should be capable of generating a storm hydrograph.

3) The model should fairly accurately predict the relative change in runoff characteristics from a pre-to post-development condition.

There are numerous hydrologic simulation models that exist in the U.S. that would provide the information that is needed to assess the impacts of development. The model most commonly used to provide the information is the Soil Conservation Service Technical Release No. 20 computer model, and the short version of that model Technical Release No. 55 (USSCS, 1975). Technical Release No. 55 can be used by the engineering community when specific site analysis is required. Two design procedures are presented by the method, those being the graphical method and the tabular method. The tabular method should be used for design purposes as it generates a storm hydrograph.

The Soil Conservation Service models generate storm hydrographs and present water quantity data. They do not present any water quality data. The status of water quality prediction models is not very well defined at this time. There are several models that exist which predict loads and those loads must be then inputted into another model to predict the impact on a receiving system. Models such as WASP (Water Quality Analysis Simulation Program) (Ambrose *et al.*, 1990) have been developed to predict the impacts

of pollutant loadings on estuarine situations, but WASP needs another program such as the Hydrologic Simulation Program (HSPF) (see Johansen *et al.*, 1980) or EPA's Stormwater Management Model (SWMM) (Huber *et al.*, 1982) to provide the input boundary conditions. These models have limitations and should probably be used only by states or regional authorities to evaluate watersheds and their water quality impacts. They can be used to evaluate potential program level decisions, but are really not appropriate to use on a case by case basis for design purposes. The limitations of the models and the required input requirements make their widespread use for design impractical.

The use of a hydrologic model that is in the public domain and accepted by the engineering community is of critical importance to the overall stormwater control program. The introduction of a new program and design model must be accompanied by an educational program to teach the design community the proper application of the design model. This function could be assumed by a university, but the impetus for the effort must come from the state or regional authority. It would ultimately be appropriate as part of an undergraduate course in engineering but initially will have to be developed for the entire engineering community.

Technical Release Nos. 20 and 55 are primarily open system design models. Where a significant portion of the drainage system is enclosed in a pipe system the rational formula still should be allowed for peak discharge design purposes. There are design models available that are primarily urban design oriented such as the Illinois Urban Drainage Area Simulator (ILLUDAS), which is a single event model based on the British Road Research Laboratory (RRL) storm sewer model. But for the purposes of evaluating the before and after conditions of a proposed land development activity, the Soil Conservation Service programs are easy to use and are appropriate for stormwater design.

9.7 Cost Estimation

Rather than repeat information that exists in other documents, one document that exists is "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs" (Schueler, 1987). The costs for BMP design, construction, and maintenance is extremely variable and the document has a good discussion in those areas. Another document that may be helpful is entitled "An Evaluation of the Costs of Stormwater

Management Pond Construction and Maintenance". These two texts provide about the best information that is available on the subject.

Two additional documents that may be of interest are entitled "Financing Marine and Estuarine Programs: A Guide to Resources" and "A Methodological Approach to an Economic Analysis of the Beneficial Outcomes of Water Quality Improvements from Sewage Treatment Plant Upgrading and Combined Sewer Overflow Controls". The issue of how to finance the implementation of resource protection programs is becoming more of an item of concern as the magnitude of the needs becomes more recognized. The most common ways that the States of Maryland and Delaware have historically addressed the resource needs is through a general appropriation by the State governments or through the use of federal funding obtained from the Environmental Protection Agency. As federal spending becomes more controlled, another funding source must be identified to maintain and improve program performance.

The two most commonly considered options include impact fees on land developers and the use of user fees where everyone pays a fee based on their type of land development and the resource needs. The impact fee is a one time fee paid by a land developer which is in addition to permit fees and waiver or exemption fees. That money is used to fund staff positions that may have an indirect relationship to the regulatory program and function for watershed planning, monitoring, program administration, etc. The problem with reliance on impact fees to fund a significant portion of program implementation is the maintenance of program function during a recessionary period when the construction industry is inactive.

The method of funding that, at this time, seems most promising is the concept of user fees. The philosophy behind user fees is that everyone either contributes to nonpoint pollution problems or benefits from the implementation of control practices. The rates can be based on an individual property owners stormwater contribution using something similar to the c factor coefficient contained in the rational formula. The first item that needs to be addressed in the user approach is to determine the resource needs. That annual figure then determines the individual property owner rates which can then be paid on a quarterly or annual basis. Over 50 jurisdictions in the U.S. have already established user fee programs. Properties having a greater impervious area such as commercial properties can expect to pay significantly higher annual fees.

When estimating program costs, several points need to be considered.

1) Much of the cost of program implementation depends on the amount of development that is ongoing. The amount of development drives the regulatory aspects with respect to plan review and inspection.

2) One plan reviewer can review approximately 2 design plans per day for stormwater management and silt control.

3) Inspectors can inspect approximately 3 large sites per day and should visit each active construction site at least once every two weeks to ensure adequate site protection. Using this as a guide, the average inspector can reasonably handle a work load of approximately 30 large projects.

4) Constructed stormwater management systems should be inspected at least annually to determine the need for maintenance. As these structures become more numerous this work load will increase as will the need for maintenance of the practices.

5) Other manpower needs must be considered depending on the aggressiveness of the desired approach. Issues such as practice monitoring, watershed studies, and administrative responsibilities must be considered as a funding component. Vehicles for inspectors can be very expensive.

6) Aggressive enforcement can offset some of the expense of program implementation. That amount of cost reduction will depend on available legal options.

The selected funding mechanism will probably involve a combination of several different methods. A permit review fee will have to be established, an impact fee may be required, there may possibly be an inspection fee, and there will have to be a general appropriation from the State legislature. The one item that neither Maryland or Delaware has addressed adequately is the maintenance of these structures. Maintenance costs can expect to be approximately 5% of the construction costs annually. That money has generally not been set aside and large scale problems can be expected. Historically, the maintenance of these structures has been the responsibility of the land owner. Site inspections accomplished by staff in Maryland indicated that approximately 70% of the structures were not functioning as designed. Only now are the larger local jurisdictions attempting to develop a maintenance infrastructure. It is my recommendation that maintenance should be a public responsibility and that responsibility should be assumed from the outset. Before

any widespread stormwater management program is implemented, the responsibilities for maintenance should be established and funding mechanisms implemented.

9.8 Monitoring Recommendations

Monitoring is a necessary component of an overall nonpoint program. The needs and benefits of monitoring include the following reasons:

1) Monitoring is needed to assess the problems that are to be addressed by a control program. The nature of the problem will, to a large extent, determine the control strategy.

2) Specific control practices need to be monitored to evaluate their relative effectiveness in reducing the downstream delivery of pollutants. Practices such as wet ponds have been monitored and documentation is available for locations in the U.S., but variations of those practices should be monitored locally to provide a local record. Practices such as created tidal and nontidal wetlands will have to be more intensively monitored to evaluate performance.

3) A watershed that is either undergoing intensive development or is already degraded should be monitored in conjunction with the implementation of water quality control practices to assess the overall effectiveness of the control strategy.

Monitoring stations should be considered as long term stations so that changes to the water quality over time may be assessed. Samples collected at these sites should be evaluated for a wide range of pollutants with follow-up samples based on positive readings of any of the parameters. The variety of expected pollutants is well known. Attention needs to be given to suspended solids and turbidity as they are a major transport mechanism of many other pollutants. It would be good to also do some aerial surveillance after a storm event to assess which tributaries have the more significant sediment loadings and possibly the source of those sediments. It might then be necessary to target those tributaries for more intensive sediment control if construction is the culprit. If natural erosion of bare soil conditions or agriculture is the cause, then a restorative strategy must be developed and implemented. Photographs of sediment plumes would also be effective at demonstrating to the public that pollutants do enter their waters.

Monitoring of control strategies is another component of an overall nonpoint strategy. Innovative strategies are especially important to monitor to ascertain their effectiveness and the need for design modification. Ponds in general are not a high priority for monitoring as much information exists regarding their relative effectiveness at pollution reduction, but the creation of artificial wetlands does not fit in that category.

Artificial wetlands are a fairly innovative practice in the control of nonpoint pollution. They have been in use for a number of years for secondary treatment of sewage at sewage treatment plants. They are effective at removal of suspended solids, but their function for nutrient uptake over the long term is less quantified. The wetlands plants may have an assimilative capability for nutrients and have to be harvested to maintain the nutrient uptake through planting of new plants. I believe that nutrients will become more and more of a problem as the character of development and agriculture evolves. It is important that criteria for the creation of artificial wetlands be established and its performance quantified. Artificial wetlands should be constructed having slightly modified design assumptions. Those modifications can include different types of vegetation, various extended detention times, and different configurations regarding shape and depth. Monitoring the inflow points and outfall structures of the ponds will determine the effectiveness of the ponds for pollution reduction. All extraneous inflow points (even sheet flow or groundwater) to the ponds has to be eliminated for monitoring purposes. The monitoring stations themselves should have automatic samplers so that samples can be taken approximately every 15 minutes during a storm event. The samples can then be evaluated for the pollutants of concern at a testing laboratory. These stations should be operational at least four years (optimal) to evaluate long term performance.

Designs using sand filters as a particulate control practice can be monitored over a much shorter time frame as declining performance will be an indication of the need for maintenance. As these practices will primarily be used in small urban situations where the response time of the runoff is extremely short. Dry weather sampling by vacuuming the drainage area will give the particulate load entering the sand filter. A pipe outfall from the sand filter can then be grab sampled during a storm event to determine the reduction of particulate material resulting from the sand filter.

The bottom line of all these efforts to implement a nonpoint strategy is that it must work. A small watershed that has already been impacted should be retrofitted with water quality control structures to demonstrate the performance and importance of the nonpoint

program. The assessment of effectiveness can only be obtained through monitoring. This is not an effort that must be pursued immediately, but is a long term need. In both Maryland and Delaware a considerable amount of interest has been expressed in showing that these strategies will maintain or improve water quality. During program initiation, there seems to be an inherent assumption that the implementation of water quality practices will protect streams and estuaries. As the program evolves, and the magnitude of the costs are recognized, there is a greater need to document the effectiveness of the overall strategies. Over the short term, some thought should be given to the selection of a test watershed that can be used as an example of program effectiveness. I would suggest a watershed no greater than 800 hectares to minimize the costs of analysis and implementation.

9.9 Examples of Bylaws and Legal Controls

When considering bylaws in the U.S. a distinction must be made between legislation and regulation. Legislation is the legal authority to regulate some type of activity. It is approved through the logical process by a governing body. Legislation provides the framework for the development of regulations. Regulations provide specific criteria for the implementation of the legislation. They are generally developed by administrative agencies and subject to some form of legislative overview. In many states the regulations will refer to specific design manuals that provide detailed specific instructions on how to meet legislative and regulatory requirements. There are three levels of requirements which go from general to specific.

This type of hierarchy is important in an emerging field such as stormwater management. Experience will always indicate that improvements to any system can be made. The passage of legislation that is broad in its scope will allow for more ability to modify program criteria as the need arises. A cumbersome political process can seriously impair program evolution.

Examples of existing legislation and regulations include:

- State of Maryland Stormwater Management Legislation and Regulations;
- State of Maryland Sediment Control Legislation and Regulations;
- State of Delaware proposed Stormwater Management Legislation;
- State of North Carolina Sediment Control Requirements;
- State of Illinois Sediment Control Requirements;

- State of Florida Regulation of Stormwater Discharges;
- State of California Erosion and Sediment Control Handbook;
- State of Delaware Erosion and Sediment Control Law;
- State of Delaware Erosion and Sediment Control Regulations;
- Model Stormwater Management Ordinance (Maryland);
- Sample Utility Ordinance (Maryland);
- South Carolina Sediment and Erosion Control Regulations;
- South Carolina Sediment Control Regulations;
- South Carolina Stormwater Management Regulations (Proposed); and
- Prince Georges County Stormwater Management Ordinance with Fee Schedule.

There are many more examples but they tend to get repetitive as many states have used other state programs to build upon.

9.10 Publicity/Education Programs

Experience in the nonpoint field in Maryland and Delaware has indicated that the value of public education and training of impacted individuals cannot be understated. Public education results in more support for the program from an institutional and funding standpoint. Our society relies to such a large extent on its water resources that the identification of a problem as important as water quality should be of concern to most residents.

The first step needs to be problem identification. The general public needs to become aware that there are existing water quality impacts. It should be emphasized that these problems are a result of man's activities. Water quality data can be presented but visual evidence should also be publicized. A private organization in Maryland, the Chesapeake Bay Foundation, has a poster for sale showing a high altitude photograph of the Chesapeake Bay just following rainfall event. The sediment plumes entering the tributaries is graphic evidence that a problem exists. People purchase these posters and hang them in their houses. There are so many ways that the public awareness process could be developed that it needs to be integrated in all aspects of program development and implementation.

On a smaller scale, displays should be developed that can be transported to various public events around a given region. This could be a visual display that describes the nonpoint problems and local efforts to deal with those problems. This display could be taken to

fairs, outdoor events, libraries, and public buildings. At the same time presentations could be given at civic type functions such as community meetings, garden clubs, and nature groups to discuss the nonpoint issues. These groups frequently are looking for speakers at their regular meetings.

The construction of demonstration projects would be another excellent opportunity to demonstrate the types of practices and strategies that are needed. These implementation projects should be located around the region where field trips could visit. Upon completion of construction, signs should be prominently placed that briefly describe the project, and the fact that it was constructed by the state or regional authority as a water pollution control project. Using a school site as a water quality project provides multiple benefits. Water quality improvement can be expected and the students receive an educational tool. One project that I was involved in was the construction of an artificial wetland at a local school that captured the pollutants from the school parking lots. The students assisted in the planting of the wetland community, and are new engaged in water quality monitoring of toxics. They are learning the types of pollutants that are generated from an urban environment, and one strategy for reducing their movement downstream. The created wetland is functioning as an outdoor laboratory for the school's biology department.

Implementation of a regulatory program for water quality will necessitate a significant educational program for those individuals impacted by the program. The engineering community has to be educated regarding the need for the regulatory process, and the proper engineering design. This can be accomplished by the development of design standards and example situations, but seminars and workshops will also have to be a regular component. An annual event such as a conference or seminar is an excellent avenue for information dissemination. Components of this conference could include design workshops, new innovations, case studies, and general information. If all impacted groups become involved, the seminar can become a mechanism to foster communication between normal adversarial groups such as land developers and environmental groups. One seminar previously discussed that is becoming more popular in the U.S. is the contractor certification program. In addition to the excellent forum for discussion and feedback from the individuals in the field who are responsible for the construction and maintenance of the sediment and stormwater practices, a number of the standard practices have been modified due to feedback from contractors.

Fostering communication between the state or regional authority and environmental groups is of vital importance. Those groups can become strong advocates of budgetary and

personnel requests. Both Maryland and Delaware established environmental associations called Save Our Streams and Streamwatch to champion environmental water quality issues. Funding and staff support was provided to those groups until they could assume an individual identity. In Maryland, Save Our Streams has become a strong independent environmental watchdog. In numerous situations they have provided needed political support for State environmental initiatives. It must be recognized that these groups are volunteer by nature and every effort must be made to fit in the average individual's off-work schedule. If established and funded adequately, these organizations may achieve a measure of independence after 5 years and they may not always agree with your efforts. Environmental groups tend to push the regulatory agencies into environmental protections programs sooner and more aggressively than the agency would have without the outside influence.

In all aspects of public education simplicity is the key. You must keep the sessions relatively short with a major emphasis on entertainment. People will only learn if you can keep their interest and too much information will only lose their interest. The same philosophy is true regarding technical sessions. Too much information in too short a time frame will lose its value and the educational process is the most important aspect of the nonpoint program. To some degree you are asking people to change a life style to reduce their impacts to the natural ecosystem. Voluntary cooperation and support is so important to the implementation of a nonpoint pollution program for such areas as waste oil disposal, lawn fertilization, and chemical disposal. A regulatory mechanism is essential in certain situations, but people must also accept and understand the need for the program.

One mechanism that should be pursued is a newsletter or publication of some sort that serves as a vehicle for communication to outside interests. There are a number of periodicals that relate to the Chesapeake Bay and the State of Delaware publishes a magazine called the "Delaware Conservationist" that is issued four times a year. This type of document can discuss results, ongoing efforts, and proposed projects and strategies. An interested party list could be established so that copies of the newsletter could be circulated.

9.11 Environmental Response Measures

NOTE: Much of the information in this section comes from a short course held by EPA in October, 1988 on Rapid Bioassessment where handouts were provided.

POLLUTION CONTROL IMPLEMENTATION

As mentioned earlier, the most important product of a nonpoint program is that the quality of water be maintained, and in certain situations improved. How to measure that improvement will also be an integral part of program implementation. A strict measure of water quality is one component of an overall assessment strategy, but the inclusion of a biological monitoring strategy to characterize aquatic systems and assess stream health trends is also important. If good water quality is the goal, what better way to measure its quality than to measure the ability of aquatic organisms to exist in that stream system. Biologic communities are probably the best indicators of overall stream health (biological, chemical and physical) and they can be used to directly measure that health.

The major reason that biologic communities provide such an accurate measure of stream health is that they reflect the impact of all water quality stresses on the ecosystem. Where water quality measurements will tell you the levels of specific pollutants, biological monitoring will give the cumulative impacts of all pollutants on the stream ecosystem. Biological monitoring will also present impacts that show a historic pattern or where sporadic levels of pollution occur.

There are two other major benefits of biological monitoring over conventional water quality monitoring. The first benefit is economic. Going out and sampling the diversity and abundance of organisms that exist in a given reach of a stream system is far cheaper than taking water quality samples and having to perform laboratory analyses. The biological monitoring (biosurveys) can serve as a first cut to determine the relative health of a stream system. If that system is seriously impacted, water quality sampling should be accomplished to determine the cause of stream system stress. The second benefit has to do with public acceptance. Specific levels of pollutants have little meaning to the general public, but lack of stream diversity and abundance can be easily understood. Recognition of the types and abundance of organisms that should exist in a healthy aquatic environment, and comparing what actually does exist in a specific stream system can be clearly understood by the average person (education again). There may be many situations where no water quality data exists for a given stream system and biosurveys are the only reasonable alternative.

In the same regard, biosurveys can also assist in the measurement of system impact after water quality retrofitting has been accomplished in a specific watershed. Any change in either the diversity or abundance of aquatic organisms will provide an indication of value of the water quality control structure. A high level of redundancy is an indicator of poor community structure and is evidence of either habitat deficiency or pollutant impact. A diverse population is an indicator of good community structure.

CHAPTER 9

There are three components of biologic monitoring that form the structure of a biosurvey. Those components includes:

- Habitat - diversity and abundance are dependent on the ability of biologic organisms to find adequate shelter with conditions suitable for reproduction;
- Benthic macroinvertebrates - looking for bugs. These bugs are good indicators of localized conditions and reflect short-term environmental variations. As they are a primary food source for many fish their communities are generally abundant.
- Fish - The presence or absence of fish provide a good indicator of long-term effects and conditions over a broad watershed area. Identification of fish is relatively easy and fisheries communities are more of interest to the general public.

The uses of these indicators in conjunction with each other have to be considered with respect to:

- If habitat effects are detected, can they be reversed? The most common example of habitat impairment would be excessive sedimentation of the stream channel.
- If biologic impairment exists, can the effects of habitat quality be separated from water quality impacts?
- Is further water quality study necessary?
- Is there a basis for enforcement action?

Two documents that may provide some further insight into biological monitoring are "Water Quality Assessment of Streams Using a Qualitative Collection Method for Benthic Macroinvertebrates" and "Methods for Rapid Biological Assessment of Streams".

Another point to mention is the consideration of nutrients in addition to the biologic monitoring to provide a more complete picture of stream health if there is the potential of a nutrient problem. Dissolved oxygen (DO) meters should be installed on a stream for two to three days to determine any fluctuation of DO readings that would indicate a nutrient problem. Algae growth has respiration all the time which uses available oxygen in the water. During periods of sunlight, algae also produces oxygen through photosynthesis so that high levels of DO would be expected during the day time. At night the algae use the available oxygen through respiration and DO levels reach their

lowest levels. As oxygen starvation may be the limiting factor on biologic productivity in a given situation, low DO may be the problem. This may be especially true in areas downstream of sewage treatment plants.

9.12 The Role of Wetlands

The role of wetlands needs to be expanded in the nonpoint pollution field if water quantity/quality protection is to be realized. Nationwide, wetlands have been severely impacted due to rural and urban land alteration or reclamation. The replacement, improvement, and creation of wetlands, both tidal and nontidal, can mitigate adverse water quality impacts in many locations. In the Chesapeake Bay and Delaware River nutrient uptake provided the principal incentive for development of wetlands creation criteria. Wetlands can provide a major tool in the treatment of urban and rural runoff for control of nonpoint pollution.

In addition to nutrient uptake, wetlands provide a significant benefit regarding the removal of suspended solids and trace metals. Suspended solids are sediment particles that are being transported by stormwater runoff. In ponds, suspended solids have two velocities associated with them: the horizontal flow velocity towards the pond outlet, and the vertical or settling velocity. The object of a water quality stormwater pond is to hold the suspended solids in the pond until the settling velocity allows for sedimentation to occur. Wetland ponds, having a dense growth of aquatic vegetation further reduce the velocity of horizontal flow to improve the sedimentation process. Smaller sized suspended particles will be removed in a wetlands stormwater basin than a comparable basin having no wetlands vegetation.

Trace metals attached to the suspended solids through cation exchange and adsorption will settle out with the suspended solids during the sedimentation process. A number of processes can then occur to the trace metals by way of anaerobic and aerobic conditions. Trace metals are taken up by the roots of the wetland vegetation and translocated to other parts of the plant. The accumulation of metals in the soils and plants is not entirely clear and long-term monitoring may be necessary to determine the possible mobility of the deposited trace metals.

In addition to their water quality benefits, created wetlands have strong habitat value and the population in general relates well to the presence of wildlife. With the acceptance that stormwater controls are a necessary component of the urbanization process, habitat considerations can be easily provided especially in urban areas where such habitat may not be abundant. In addition to providing habitat, wetlands basins can provide sources of food in insects, seeds, and plant parts. These sources of food attract birds and animals with birds being the primary beneficiary.

9.13 Conclusion

The issue of nonpoint pollution control is not a question of whether there is a need, but rather when is society ready to face that need. I am amazed in the U.S. that we are so willing to accept a lower standard of life than we have to. Problems have to be critical before we begin to address them. The solutions to those problems become so much more difficult, and our ability to address those problems becomes very limited. The solutions at the critical stage tend to be primarily engineering solutions that are extremely expensive with space allocations non-existent. The time to address the problem is when the problem is recognized, not some time down the road when our solutions become more extreme. The overall costs to implement a water quality protection program are so much less than the costs to restore water quality to an earlier, higher standard. The problem is not going to just go away. The sooner it is faced, the less painful the solution will be.

It is also important to recognize that a number of years will be required to get all the necessary elements working together. This type of program cannot be implemented overnight and there are many linkages with other existing programs and those linkages must be coordinated. So often, adversarial relationships develop between program components and the overall effort is diminished. Positive coordination in this era of fiscal restraint is critical if progress is to be made. My experience has indicated that there are many growth pains associated with the development of a nonpoint program and sorting out areas of responsibility take time. That is another reason that efforts should be started soon to address the issue. Time will be lost getting the program established, and water quality concerns will increase. A crisis approach must be avoided if at all possible.

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CHAPTER 10

Performance, Safety and Maintenance Aspects of 0-25 Year Old Ponds in the City of Winnipeg

E. Klassen

ABSTRACT

Following the introduction of retention ponds in the City of Winnipeg by land developers some 25 years ago, the City hired consultants to develop master drainage plans for each of the 25 watersheds. With increasing distances between new developments and receiving streams, economic analyses favoured retention ponds over large-pipe systems. Fifty-five ponds currently exist, with the addition of one to two each year.

The design basis of the ponds was to provide storage of large stormwater flows to minimize the required size of trunk storm sewers. Design has recently also considered recreation, maintenance, economics, and water quality.

The City monitors the ponds regularly each year. It conducted two major studies, the most recent on 15 year old ponds, which provided insight into their pollutant removal effectiveness. For example, suspended solids and BOD removals were in the order of 90 and 60 percent respectively. Lead was reduced 85 percent. Sedimentation occurred at a rate of up to 20 mm per year.

In terms of safety, the design has been quite adequate for the designated use of secondary contact recreation which excludes swimming and wading. While maintenance has been relatively inexpensive, aquatic plant growth is gradually increasing and will require more frequent treatment.

10.1 Background

When developers first introduced stormwater ponds in 1965, the intent was to make subdivisions more marketable by creating lakefront property. Shortly thereafter it was

determined that a further benefit, for lands remote from the river, was the reduced capital cost over large pipe systems. Another advantage, not initially recognized, was the degree of pollution reduction available.

The increasing popularity caused the City to establish guidelines for the design and safety of these impoundments, since each was associated with adjacent public parks. Maintenance programs were also established and in addition to regular summer monitoring, two major evaluations were conducted.

10.2 General Guidelines

Two important events occurred in the 1970's in relation to land drainage. Firstly, with amalgamation of all cities and municipalities in 1971, it was possible to complete regional land drainage plans. Master plans were developed for 43 regional watersheds. Secondly, Council approved a bridge-financing plan, under which a developer would be required to 'front-end' regional land drainage works, with repayment by the City or other developers. Each developer was charged a trunk service rate, based on the value of the regional system and the area of a development. Under this process, some 55 impoundments have been developed, mostly by developers, and cost-shared by benefitting lands.

Following limited experience with dry-bottom ponds, the City quickly decided to accept only wet impoundments. This was largely due to the inconvenience of runoff-interrupted use, and relatively high maintenance and cleaning costs.

A minimum size of 2 hectares was imposed for aesthetic and maintenance reasons. A minimum depth of 1.2 metres was selected based on an APWA draft report on "On-Site Detention Systems" from the point of view of algae development, aquifer contamination, water turnover, fish stocking, sedimentation and drainage. Until recently, 50 percent of the shoreline was designated as public park and 50 percent private lake frontage. Because of high public maintenance costs, the public portion has been reduced to 25 percent of lake frontage. Finally, the hydraulic design allows for a 1.2 m rise in water level during a 25-year rainstorm, with a further freeboard of 0.6 m for a 100 year event.

10.3 Performance

It is difficult in assessing long-term changes in impoundment water quality to account for all parameters that can impinge on the results. Meteorological conditions such as precipitation, temperature, and amount of sunlight have a significant bearing. Physical conditions can have significant impact, - among them the degree of development completion in a watershed, the amount of debris (sand and salt) from winter operations, the level of street cleaning during the summer, the number of pets in a neighbourhood, and the number of birds and animals in the watershed. Even the presence of a fountain in a pond can affect the water quality.

Many impoundments in Winnipeg were built in chains, for economic and hydraulic reasons. Thus the detention times in impoundments vary. Furthermore, inflows to each pond are not necessarily located at each end. There may be two or more inlets to an impoundment. Sampling locations therefore become extremely important, and even then the averaging of results will tend to dilute site-specific data. Inlet and outlet conditions and the configuration of the ponds can affect various parameters, including detention times (short-circuiting) and sedimentation rates. Nevertheless, certain conclusions have been drawn, over a period of time, that define trends in water quality.

The early years of impoundment use saw little obvious need for quality and use assessment. However with increasing numbers of ponds, and their increased use by the public, it became apparent that guidelines would be required. Thus in 1975, Council approved guidelines for the construction and use of impoundments (Chambers and Tottle, 1980). This led to a major assessment in 1976 (Penman, 1975). A more scientific and detailed evaluation was completed in 1980 (Pond and Tottle, 1975) with the assistance of the Canada Mortgage and Housing Corporation and Environment Canada. Since then the City has carried out an annual monitoring program. Indications are that eutrophication is accelerating, and a major review will be required soon to ensure that the initial objectives of impoundments continue to be met.

10.4 Monitoring and Sampling

The City has used a variety of equipment over the years to monitor the ponds. In terms of rainfall, during the major studies, each of the two sites had an independent Type MSC

Recording Tipping bucket rain gauge. At present, the rain gauging network consists of 21 strategically located automated and centrally-recording rain gauges, which are used for a variety of functions, including combined-sewer overflow studies.

Flows were recorded by Foxboro Model 40 Level Recorders at temporary weir installations and the automated wastewater samplers, each capable of taking 12 samples, were designed and built by the City. Field crews were available on a 24-hour basis to ensure timely collection of samples. Benthic samples were obtained with trays or Hester - Deudy Samplers. Sediment samples were acquired with a clam bucket dredge and core sampler. The fish survey used gill and seine nets, and was carried out with the assistance of Environment Canada Freshwater Institute.

In the two major studies referred to, inflow sampling points were located at the top end and/or along the chain of ponds. Outlet samples were collected where the lake chain discharges to the receiving stream.

General meteorological conditions were as indicated on Table 1.

1. BOD

The initial testing of impoundments used 5-day BOD as a pollution indicator. This was later changed to TOC, on the basis of an empirical correlation between BOD and TOC. In one specific drainage system (Clearwater Lake), BOD and TOC were as shown on Table 2 in the earliest study. BOD removals were 83 percent. Studies of a second 2-pond system (Baldry) showed removals of 73 percent. In the second major study, BOD removal efficiencies for the two systems were 75 and 30 percent respectively. For Clearwater Lake, with the longest continuous monitoring, the average TOC's varied as shown on Table 3.

2. Suspended Solids

Recent monitoring has not included suspended solids. However, the two earlier studies for Clearwater Lake showed removal efficiencies of 85 and 94 percent respectively. The Baldry system with a lower detention time had removals of 73 and 85 percent. Turbidities in the two systems have shown no significant changes since 1977.

Table 1

METEOROLOGICAL CONDITIONS - WINNIPEG

Month	Normal Rainfall mm	Normal Snowfall cm	Mean Temperature (°C)	Lake Evaporation mm
January	0.3	24.9	-18.3	0
February	0.8	19.8	-15.7	0
March	6.1	21.1	-8.1	0
April	25.4	11.9	3.3	0
May	54.6	2.5	10.6	101.6
June	80.3	Trace	16.5	132.1
July	80.3	0	19.7	154.9
August	73.7	0	18.7	129.5
September	52.6	0.3	12.6	86.4
October	29.2	5.6	6.6	50.0
November	7.1	21.3	-4.4	0
December	0.8	23.9	-13.7	0
Mean			2.3	
Total	411.2	131.3		655.3

Source: Fisheries and Environment Canada,
Atmospheric Environment Service (Pond and Tottle, 1975)

Table 2

1974 WATER QUALITY - CLEARWATER LAKE

Date	BOD mg/L	TOC mg/L	Turbidity J.T.U.	DO mg/L	Total Coliform
June 27/74	4	10	3	7.8	350
July 25/74	-	6	3	5.6	-
Aug. 16/74	4	3	16	-	380
Aug. 27/74	5	12	18.0	8.0	-
Red River (for comparison purposes @ Norwood Bridge (summer)	-	15	40	9.0	24,000

Source - City of Winnipeg (Penman, 1975)

Table 3

TOC VARIATIONS

	1974	1977	1983	1985	1987
Clearwater	8.0	25.6	19.0	11.0	16.0

3. Dissolved Oxygen

The earliest tests in 1975 for dissolved oxygen indicated that it was at or near saturation levels which for water temperatures of 25°C were normally above 8.0 mg/L. The more detailed assessment in 1977 showed saturation levels of 47-100 percent. Since then median levels have been fluctuating between 7.0 and 9.5 mg/L. In the 1985 and 1987 assessments, oxygen levels for the above ponds, as for all impoundments were measured at the surface, mid-depth and at bottom. There was a nominal decrease, on average, of oxygen levels with depth.

Fish life exists in most impoundments, as a result of upstream migration from the receiving stream or possible stocking by residents. The ponds with generally high oxygen levels have pike, while others have a variety of coarse fish such as bullheads and carp with lower oxygen requirements. Fathead minnows were observed and are recognized as playing a role in controlling mosquito larvae.

4. Metals

While recent monitoring has not included metals, both the 1976 and 1980 assessments included lead. The more detailed 1980 evaluations calculated lead removals of 89 and 80 percent in the two pond systems. With the exception of nickel, all metals fell within limits set for domestic consumption. Table 4 summarizes the water quality parameter concentrations.

5. Aquatic Plant Growth

Data show that the rate of plankton growth increases with increased pond-age and eutrophication. Early studies showed that nitrogen and phosphorus were stored in the sediments and would thus be available for plant growth in subsequent years. On an annual basis, algae growth increased with temperature, with blue-green algae being the most dominant (eg. anabaena). Increasingly, odours have been detected and it is expected that blue-green algae may contribute to this.

The same trends have occurred with weeds such as cattails. Harvesting of weeds has occurred for a number of years. Initially this was done manually. In 1989, mechanical weed harvesting was tested. Table 5 shows some of the results.

Table 4

WATER QUALITY PARAMETER CONCENTRATIONS

Parameter	Maximum or Range of Concentrations: Clearwater	Baldry
pH	5.0 - 9.3	5.0 - 9.0
True Colour	5 - 50	10 - 70
Turbidity	4 - 77	9 - 115
Threshold Odour Number	2 - 14	2 - 14
Dissolved Oxygen	47 - 100% saturation	47 - 100% saturation
Lead	0.05 mg/L	0.05 mg/L
Chromium	0.05 mg/L	0.05 mg/L
Cadmium	0.01 mg/L	0.01 mg/L
Zinc	5.0 mg/L	5.0 mg/L
Copper	1.0 mg/L	1.0 mg/L
Nickel	0.2 mg/L	0.2 mg/L
Chloride	250 mg/L	250 mg/L
Nitrate	10 mg/L	10 mg/L
Total Coliform*	The median (50 percentile) based on not less than 5 samples per month was not greater than 500 MPN per 100 mL.	(same as Clearwater)
Fecal Coliform*	The median (50 percentile) based on not less than 5 samples per month was not greater than 200 MPN per 100 mL.	(same as Clearwater)
Total Plankton	90 - 30 800 ASU/100 mL	100 - 23 900 ASU/100 mL
Blue-green algae	10 - 22 300 ASU/100 mL	30 - 22 950 ASU/100 mL

ASU - areal standard unit
MPN - most probable number
* acceptable for primary contact recreation (swimming)
Source: Evaluation of Stormwater Impoundments (Pond and Tottle, 1975)

Table 5

WEED HARVESTING - 1989

Location	Lake Area Harvested (Hect.)	Removal Tonnes (Total)	Tonnes per Hect.	Harvest Time Hrs.	Weed Type
R 4-2	6.9	25.5	3.7	30	Pondweed Coontails
D 3-2	3.4	17.3	5.1	28	Pondweed Cattails
D 3-4	2.6	22.5	8.6	15	Pondweed Coontails Filam.Algae
5-7	1.2	6.1	5.1	5	Variety
Harbour View	2.1	25.5	12.1	16	Pondweed Filam.Algae

The mechanical weed harvester performs efficiently and provides immediate aesthetic improvement.

6. Sedimentation Rates (Sediment Burial Rates)

With the exception of the two major assessments, routine sampling has not included sediment samples. In the 1976 study, it was determined that the average sediment accumulation rates were 41 mm over the 12-year life of the pond. Over the two years of data collection, the actual rates were 20 mm per year. These varying rates were attributed to maturing (filling) of development over that period. The study further predicted a long-term volume accumulation rate of 25 m3/ha of serviced area per year. Assessments have not been made to verify this. There is no question that sediment removal will become part of the long-term maintenance program.

7. Coliforms

The earlier studies indicated that the mean values for total and fecal coliforms were within the limits suitable for primary contact recreation, although concentrations occasionally exceeded them. Possible sources were thought to be cross-connections, domestic and wild animals in the service area and decaying plant material. Extensive investigations eliminated the presence of cross-connections.

A review of data to date continues to show concentrations beyond allowable primary contact limits. In 1987 for example, a total of 400 samples were taken for all lakes. Of these, the mean counts for total coliforms nominally exceeded 500 on 49 occasions. Fecal coliforms exceeded 200 on 33 occasions by nominal amounts. The earlier studies had shown that higher bacterial levels occurred in bottom and mid-depth samples following heavy rains. These levels diminished significantly with time.

Based on these data, and on safety and practicality, primary contact recreation is not a consideration for the future.

In summary, typical treatment efficiencies are shown on Table 6.

Table 6

ANNUAL TREATMENT EFFICIENCIES

Water Quality Parameter	Clearwater (percent loading removed)	Baldry (percent loading removed)
Suspended Solids	94	85
Total Organic Carbon	21	50
Five-Day Biochemical Oxygen Demand	75	30
Total Kjeldahl Nitrogen	22	26
Nitrate (NO_3)	83	71
Total Phosphorous	51	60
Chloride	-149	-618
Lead	89	80

Source: Evaluation of Stormwater Impoundments (Pond and Tottle, 1975)

10.5 Safety

With the exception of one fenced deep pond, all impoundments have public access, in addition to privately-owned residential lake frontage. Public safety has therefore been of prime concern from the beginning. As noted above, earlier assessments of water quality were made to ascertain a safe and acceptable designated use for impoundments. These resulted in allowing secondary contact recreation, - thus excluding swimming and wading. The public portions of all ponds were therefore posted accordingly.

It was nevertheless expected that the public would be attracted to the water's edge and a slope of 7:1 was considered non-hazardous, even for toddlers. (From a slope-stability point of view, this slope was also considered reasonably stable). While the depth at times exceeded 2 metres, the flat slope eliminated any sharp changes in depth. The placement of granular revetment had two-fold benefits, - the protection against erosion and discouraging of water-entry by the public. In addition, it looks attractive and provides a grass mowing edge.

All adjacent public parks were posted, to prevent swimming, wading and power boating.

A vulnerable safety area around impoundments was the piping into and out of each pond. Such circumstances occurred where a chain of impoundments was constructed and where roadways crossed such inter-connections. In these instances, the safety standards of the pond were compromised by steeper slopes and the direct access by the public to deep water. The drowning of a child at one such location resulted in a judicial inquiry. While the City was not held responsible, the recommendation by the judge of fencing such vulnerable areas was quickly acceded to. Conduits are required to be submerged.

In terms of legal liability, it is the opinion of the City's legal advisers that the water in the impoundments is "not owned by the City" and that its presence is not grounds for liability. With the exception of the above, there have been no known instances of safety abuses, and no legal actions against the City. There have been no reported incidents of medical problems as a result of human contact with impoundment waters. The City in fact uses certain impoundments for the instruction of sailing and canoeing classes under supervised conditions.

10.6 Maintenance

The somewhat arbitrary introduction of impoundments into Winnipeg gave relatively little consideration to long-term maintenance problems. Very quickly however, experience dictated that like any other public service, regular care and attention was necessary. Since 50 percent of most ponds was public park which encouraged public accessibility, litter control became a high priority with the public as well as private waterfront owners, who beautified their properties and were concerned about the deterioration of the appearance of the public portions.

The City thus quickly developed an organized approach to maintenance and enhancement of the public waterfront and associated parks.

The Parks and Recreation and Waterworks, Waste and Disposal Departments jointly shared these duties. Firstly, these departments co-operated with developers in establishing minimum standards in the development of impoundments. Sodding and planting standards were established. Soil sterilization to prevent initial aquatic growth was introduced. While the Waterworks Department had prime responsibility for impoundments including budgeting, the Parks Department, with the expertise, provided the assistance in preventing and/or controlling weeds and aquatic growth.

The City currently has 55 impoundments consisting of 120 hectares of water and 95 km of waterfront property. Approximately 50 percent of this is publicly controlled and maintained. The annual maintenance budget is $150,000 or about $1250 per hectare of pond.

This comprises mainly a 3-person seasonal temporary crew, together with funding for the operation and maintenance of the impoundments and the replenishment wells, 3 pumping stations and 8 fountains. General duties include signing of new impoundments and the changing of seasonal signs for related uses. Inter-connecting culverts require cleaning and maintenance. Pumps for fountains and wells require on-going maintenance, repairs and seasonal removal. Fountains also require regular maintenance, removal, storage and re-installation. All control gates are regularly exercised, and outfalls are cleaned, checked and properly signed.

While mechanical maintenance is a planned and structured activity, litter and aquatic growth demand continuous attention. On an annual basis some 35-40 tonnes of litter are collected and disposed of at landfills. This requires bi-weekly surveillance and collection, and involves litter on public property and the impoundments proper.

Aquatic growth in the ponds, as in most shallow water bodies, begins very slowly. No action was taken for some years after the initial installations. In fact the Council-accepted report on guidelines (1975) indicated that "plant and algae control has not been a problem in the Winnipeg installation". Starting 15 years after the introduction of impoundments, algae and weed control was started. Although water depths were initially planned to minimize light penetration and growth, the conditions were increasingly conducive to vegetation. Low precipitation years have resulted in turnover rates as low as 0.7 times per year, and temperatures and nutrients, together with the "natural seeding" of plants has resulted in a proliferation of algae (eg. blue-green) and submergent and emergent aquatic plant growth.

The lakes are inspected bi-weekly for aquatic growth during the summer. Based on these inspections chemicals are applied. While copper sulphate was applied until recently, it is no longer acceptable provincially, so that CUTRINE (which is also copper-based) is utilized for algae-control. Weed growth is controlled by the use of SIMAZINE where possible. Other chemicals used for specific purposes are REGALONE A, 2-4-D, and AQUASHADE.

Chemicals are applied in a site-specific manner. The existence of shoreline trees and shrubs, for example, limit the use of certain chemicals. Furthermore, the existence of fish, and increasing public awareness and interest in the aquatic environment has complicated treatment for aquatic growths.

The conditions of the past several years (including high temperatures), have caused unusually large masses of weed growth. For the first time in 1989, the City experimented with weed-harvesting by private contract. In this process, weeds are cut and removed from the pond. The success of this process has been inhibited by flat slopes (7:1) and hence shallow water. Harvesting with the specific equipment used by a contractor is not effective in water of less than 0.3 metres in depth, which leaves a 2-metre unharvested strip on the periphery.

10.7 Conclusions

The presence of impoundments has provided safe, economical land drainage systems, a significant amount of pollution reduction, and a highly desirable aesthetic amenity. The cost of maintenance, relative to the benefit, is considered low. Considering the high degree of public access, the impoundments have not posed a health or safety hazard.

The continuation of these benefits will depend on continued monitoring and the necessary action to counteract eutrophication. It is expected that a major review will be undertaken in the near future, with special emphasis on control of aquatic growth and sedimentation.

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CHAPTER 11

Disinfection of Stormwater

David Brierley, Godknows Itamunoala and David O. Mallen

Urban runoff contains various contaminants which historically has been treated by the construction of wet ponds to provide detention time for the settlement of suspended solids. A side benefit has been a reduction in bacterial densities and particulate forms of metals and organics through settling and decay processes. Nevertheless, swimming restrictions continue to be imposed throughout the summer in major urban centres because water quality guidelines in respect to coliform content are not being met.

Alternative control techniques include larger ponds or disinfection. Larger stormwater retention ponds are either physically impossible due to pre-existing urban development or too consumptive of valuable land. Disinfection is hence the plausible alternative. Disinfection of treatment plant effluent has been achieved in the past through chlorination, ozonation, and ultra violet irradiation. Its implementation in stormwater is limited, at the moment, by the lack of practical experience derived from operating such facilities.

This paper examines the desired benefits and presently observed problems associated with the disinfection of stormwater.

Disinfection of stormwater has been identified as required to achieve a swimmable water quality at beaches in regions such as Ottawa-Carleton. Some bacterial reduction is achieved in Stormwater Management (wet) ponds through settling and decay processes but these devices provide insufficient treatment in a practical way, necessitating disinfection. Special emphasis is placed in the paper upon ultraviolet radiation disinfection and a comparison to other disinfection techniques, because this technology was tested for the City of Nepean in the Ottawa-Carleton area. [Editors' Note: Based on the results of a pilot study, an ultra-violet disinfection system was designed and constructed in the summer of 1992 at the Longfields - Davidson Stormwater Pond in Nepean.]

CHAPTER 11

11.1 The Reasons for Disinfection

Stormwater runoff generally contains a pollutant load of some measure, whether it be sediment in mountain streams or salt in highway drainage ditches. In rural areas, runoff is likely to contain a high bacterial content as a result of livestock operations. In urban areas pollutants arise from several sources in both solution and particulate form:

- Inorganic material
- Organic nutrients
- Heavy Metals
- Bacteria

To date most of the effort in stormwater treatment has been put into the removal of suspended solids (SS) through detention of urban runoff and even to the treatment of industrial runoff with sand filters. These methods have generally proved successful in reducing the quantities of heavy metals, organics and bacteria as well as SS. But in heavily developed urban settings the concentrations are often so high, the land so scarce or the receiving water quality so low that physical treatment alone may not be sufficient nor the space available for use of passive technologies dependent upon sedimentation.

When bacterial levels become high there is a risk, not only to those drinking the water but also to those in contact with water through bathing or other recreational water uses (wading, boating). The bacteria present can cause skin irritations and even gastrointestinal disorders such as gastroenteritis.

11.2 Effects of Pond Storage

Animal droppings, principally from pets and birds, are the common source of urban bacteria loadings. Research carried out jointly by the Regional Municipality of Ottawa-Carleton and Ontario Ministry of Environment (MOE) has revealed that, unlike other pollutants, bacteria levels do not exhibit a high "first flush" response to rainfall but rather tend to increase as rainfall continues. The initial hypothesis is that the presence of water and nutrients causes the release and growth of bacteria from the droppings (GS/PR, 1982).

Similarly, on entering a pond system, the bacteria have been seen to undergo an exponential increase in numbers over the first day or so. This pattern sketched in a generic way in Figure 1 is thought to be due to the bacteria feeding on the waterborne nutrients. After this period, they undergo a steady decline which is attributed to the food being used up (MOE, 1983; Gietz, 1988; RMOC, 1988). The problem is that, depending on the rainfall pattern, the number of dry days preceding the rain, time of year, etc. the residual fecal coliform level after three days may be as low as 100 counts or as high as 3000. (Fig 1).

Measurements taken from detention ponds have demonstrated that the Fecal Coliform count exceed the provincial recreation water quality guidelines 90% of the time that rainfall exceeded just 6 mm. Research also showed that for these particular test catchments, the pollutant removal efficiency was greater when the ponds were operated in batch mode rather than in continuous (flow through) mode. In batch mode, up to 90% of sediment could be removed in the first 12 to 16 hours of detention, although at least 3 days were needed to show significant improvements in coliform levels (GS/PR, 1982).

11.3 Measurement of Bacteria

Research by the U.S. E.P.A. has shown that the risk of infection from contact with water containing bacteria increases when the plate count of fecal coliform exceeds 400/100 mL of water. Thus the E.P.A. has set a fecal limit of 200/100 mL for body contact standards. Using the same approach it has proposed limits for E-Coli and Enterococci counts of 126 and 33/100 mL respectively.

As a result of its research, the Ministry of the Environment in Ontario has set bacterial limits based on coliform counts. The standards have been set at:

- Total Coliform - 1000/100 mL
- Fecal Coliform - 100/100 mL

The biochemistry of coliforms has been extensively studied and is well understood. Therefore the large body of data that exists for these microorganisms has led to their use as indicators of bacterial levels in general. In some respects, however, this can be misleading; for example one member of the fecal coliform group is found in pulp mill

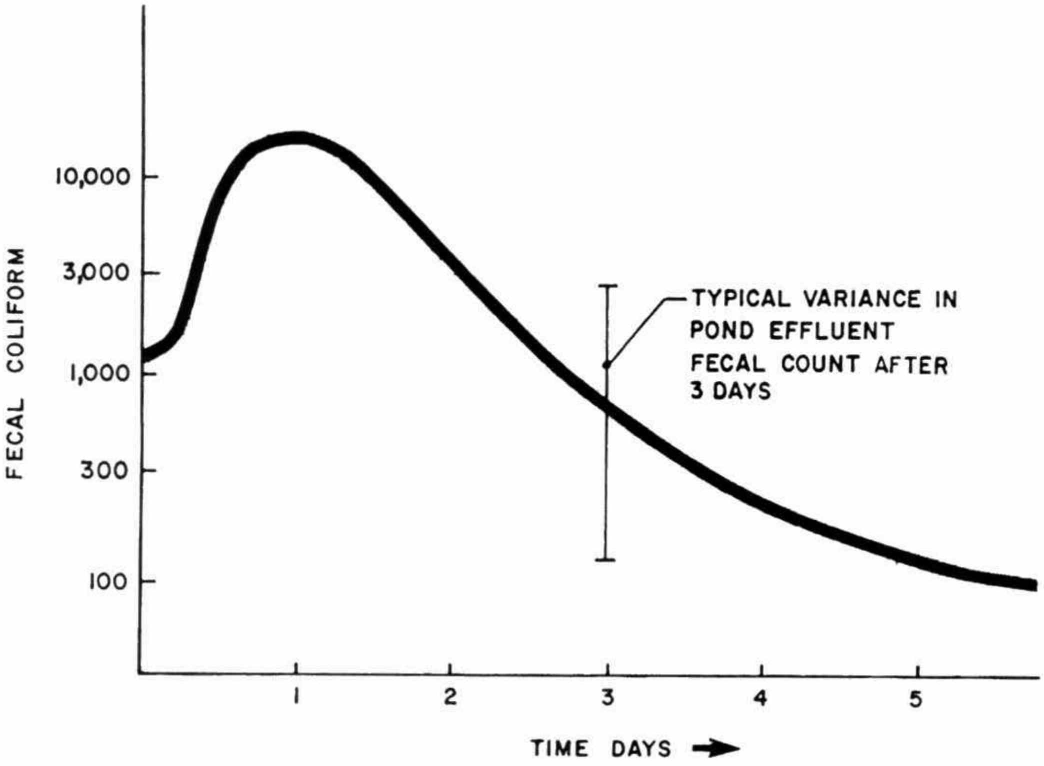

Figure 1: Typical Bacteria Growth and Decay Curve in Ponds after Storm

effluent and has no connection to fecal matter. On the other hand coliforms are at best an indicator of the potential presence of disease causing organisms of which there are many. Among the better known are:

- *Salmonella typhosa*
- *Salmonella paratyphi*
- *Shigella dysenteriae*
- *Streptococcus*
- *Staphylococcus*
- *Pseudomonas*

For some health risks, coliforms provide no indication of disease potential. Among them are viruses, tuberculosis and non-bacterial agents such as Giardia cysts.

Consideration should be given to alternatives or additions to the coliform count as the measure of risk. These could include:

- Total plate count
- Measurement of enterococchi
- Measurement of E-Coli

Of these alternatives, the measurement of E-Coli separately or in combination with Coliform is recommended. E-Coli has been studied extensively and is more directly related to gastrointestinal disorders than coliforms. Accordingly, the U.S. EPA in 1986 recommended a change to E-Coli as the measure of bacteria.

Editors's note: In May 1992 the Ontario Ministry of Health released the Report of the Recreational Water Quality Committee and the accompanying Beach Management Protocol. The committee recommended that the indicator organism for sewage pollution of recreational waters be changed from fecal coliforms to Escherichia coli at a maximum allowable concentration (MAC) of 100 EC per 100 mL of water. The MAC may be reviewed in future as more information becomes available. The recommendations in the report are being adopted for the 1992 recreational water season.

11.4 How Disinfection Works

There are two types of disinfecting methods: chemical and physical. The former include chlorine and its derivatives and ozone. The latter occurs mainly through radiation and includes ultra-violet irradiation and gamma radiation.

Chemical "oxidants" work by replacing hydrogen atoms on the DNA molecules of the cells of a bacterium with the chlorine or oxygen atoms of the unstable oxidant. When the DNA attempts to replicate, the genetic code is broken and the cell dies.

Radiation on the other hand energises the DNA molecule to the extent that either adjacent molecules on the lattice are bonded together or the lattice is broken. Again, the genetic code is disrupted, the DNA cannot reproduce and the cell dies.

11.5 Generation of Disinfectants

11.5.1 Chlorine

Chlorine is produced by the electrolysis of common salt- Sodium Chloride. It is available from the chemical industry in compressed gaseous form in one tonne cylinders. Alternatively it is available as hypochlorite salts such as sodium hypochlorite solution (bleach). A third form is chlorine dioxide (a yellow/green gas) which is unstable and thus must be generated on site making it a more expensive proposition than the other methods although it has the advantage of producing fewer harmful byproducts. All forms of chlorine must be handled with extreme care as the chemical is very toxic to humans.

11.5.2 Ozone

Ozone is a product of the ionization of air caused by the arcing of electricity in air or oxygen. The process is quite inefficient, only 2 to 3% of the oxygen in the supply stream being converted to ozone. As a relatively unstable gas, ozone is also a powerful oxidant. Ozone is less toxic than chlorine but can be disabling to humans in heavy concentrations or after long exposure.

11.5.3 Ultraviolet Light

Ultraviolet radiation is produced from discharge tubes containing Mercury vapour and Argon gas. The gases in an excited state emit electrons from the outer orbits which in turn produces radiation in the UV area of the light spectrum - approximately 250 nanometres. UV light has relatively low energy and is therefore comparatively safe to use. There is also no danger to humans from exceeding the set dose of radiation.

11.5.4 Gamma Radiation

This form of radiation is emitted from radioactive isotopes such as Cobalt-60. The radiation has a shorter wavelength than UV and consequently higher energy. It is a more effective disinfectant than UV but can also be more dangerous in terms of operation and handling. The other very important aspect of this alternative would be the public reaction to irradiated water. It is very likely that it would be no different than to the recent test marketing of irradiated food with the ensuing quandary that nobody would want their children bathing in the disinfected water anyway!

11.6 Problems With Disinfecting Stormwater

11.6.1 Flow Quantity Variation

Unlike wastewater which undergoes a diurnal flow variation of perhaps 0.25 to 3.00 times the average daily flow, storm flows may vary from nothing in dry weather to enormous volumes in periods of intense rainfall. Stormwater detention ponds play a large role in managing the rate of flow for subsequent disinfection but in the upper ranges of stormwater runoff a decision has to be taken at some point to permit a bypass of the disinfection apparatus. Otherwise the capital cost of the treatment equipment becomes prohibitively expensive.

The MOE in its interim guidelines (e.g., see Chapter 3 of this volume) has suggested that for outfalls into sensitive swimming areas, no more than four discharges should be allowed during the swimming season of May to September. This requires an analysis of the historic summer rainfall patterns to determine the intensity and duration of rainfall

events that would meet this criterion. If a pond does not already exist, its size can be optimised alongside the size of the disinfection facility to provide the lowest overall cost. If a pond already exists or one is required for flow or sediment control, then the minimum size to meet these other parameters should be assessed for compatibility with outflow rates for optimum disinfection.

11.6.2 Turbidity

Turbidity by definition is a condition that hinders the passage of light. It may be the result of compounds in solution but is more likely to be from particulate matter which is maintained in suspension by Brownian motion in the case of small submicron sized particles or by turbulence or inadequate detention time in the case of larger particles. Turbidity can affect any of the disinfection processes through shielding of the bacteria with organic material or in the case of chemical disinfectants, by neutralising the chemical. However, the biggest problem may be with UV disinfection because UV radiation is scattered and reflected back by turbidity in the same manner as white light. This drastically reduces the efficiency of the UV process and can make it uneconomical. Therefore, not only must the potential for turbidity be assessed but also the efficiency of the settlement process in eliminating the problem.

11.6.3 Disinfection Byproducts and Residuals

A lot is now known about the interaction of chlorine with chemicals in wastewater. Among the byproducts from chlorine addition are trihalomethanes and chloramines which are linked to cancer.

Excess chlorine from the disinfection process is toxic to aquatic life; for example, .028 mg/L of total residual chlorine (TRC) is toxic to certain invertebrates. Considering that typical chlorine residuals in WPCP effluents are 0.5 to 1.0 mg/L, the extent of the problem can be seen. Dilution plays a part in mitigating the effects of TRC as does volatilization but if several outfalls to a stream are chlorinated, there will be a cumulative effect. These concerns have led to the need for dechlorination of effluent.

Although the recent focus has been on chlorine byproducts, there is a growing interest in researching the affect of ozonation byproducts, principally aldehydes, and their health effects as well.

11.6.4 Removal of Disinfection Residuals

The major research to date in the area of reducing/removing disinfection residuals has focused upon dechlorination. Dechlorination is typically carried out by adding sulphur dioxide or sodium sulphite to the effluent (see Figure 2). The process can be controlled by sensors such that virtually all active chlorine species are removed. But both chemicals also consume dissolved oxygen in the effluent to form sulphates. This may reduce the D.O. to an unacceptable level and necessitate re-aeration. The process thus adds to the total chemical content of the water. Sulphur dioxide will also consume alkalinity when it reacts with water.

11.6.5 Bacterial Regrowth

It is important to note that a) not all cells die and b) natural enzymes can repair damaged cells. Given the right conditions, the bacteria will regenerate. Bacterial regeneration occurs where temperatures are high, sunlight is present and food is available for the bacteria. Hence if treated stormwater is discharged into a warm receiving stream where there is already food from pollutants in the water, it is probable, given time that there will be a significant regrowth in bacterial levels. This can be a problem in a slow moving stream that is some distance from a bathing area.

11.6.6 Technological Adaptation

It must be recognised that stormwater treatment is a new area for the application of disinfection technology. Although the processes are well understood in the fields of water and wastewater treatment, there will inevitably be new hurdles to overcome in their application to stormwater. Therefore, in the first Canadian application (Ottawa area), where the decision has been taken to install an ultraviolet system in the outfall from a detention pond, a pilot plant has been designed and tested to establish the criteria for a full scale system.

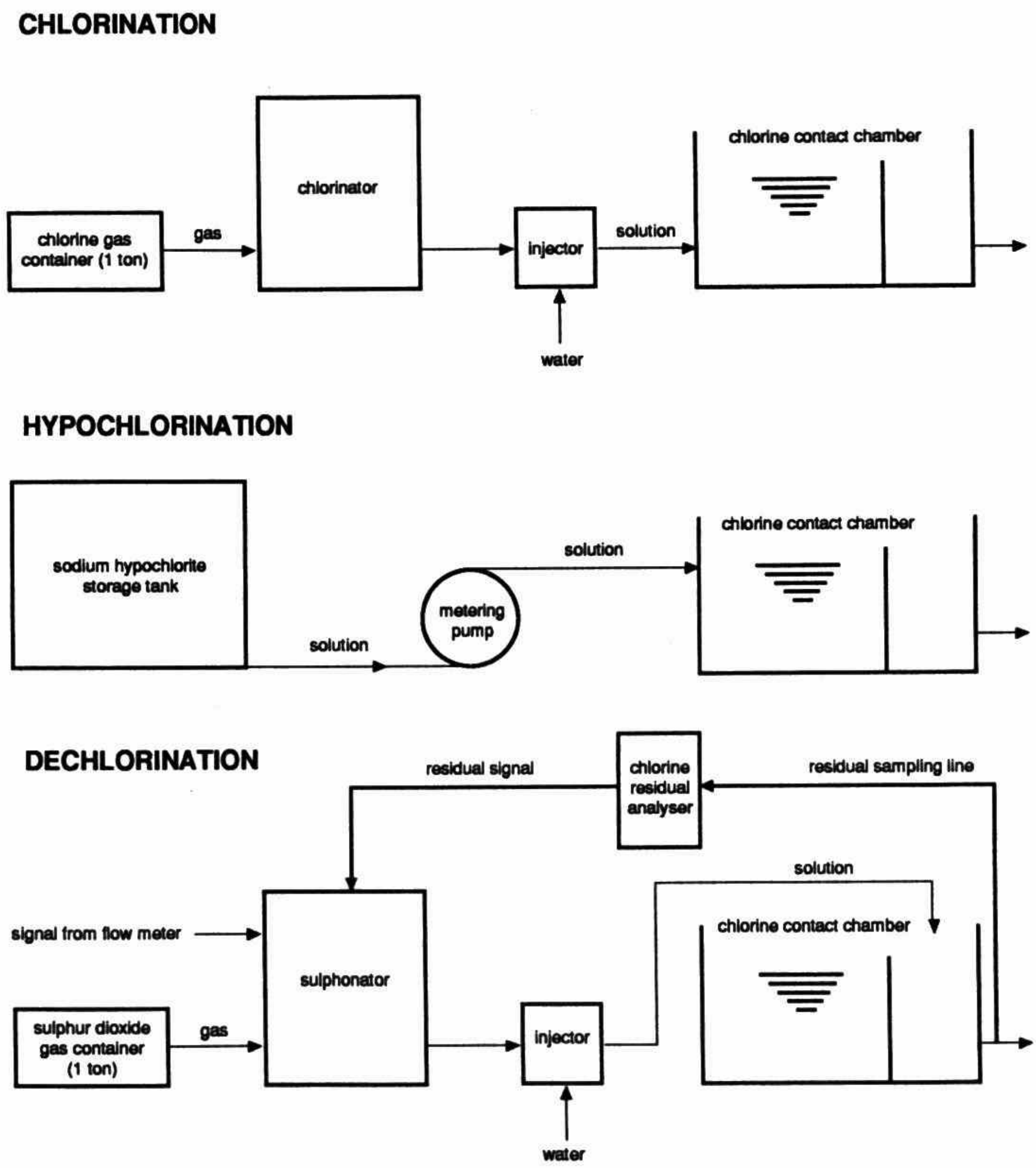

Figure 2: Techniques for Chlorination and Dechlorination

11.7 Ultraviolet Equipment

Several types of equipment are available from Canadian and U.S. manufacturers. These include submerged, closed channel pressure systems, gravity open channel units, vertically mounted UV tubes perpendicular to the flow and horizontally mounted tubes longitudinal to the flow.

The established technology is to use low pressure discharge tubes of the type used in wastewater applications. However, for stormwater the more recent development of medium pressure tubes holds some promise. As of this date however, the new lamps have not been adequately tested in an operational environment.

Some lamps come with an outer quartz tube for protection. Sliming of the lamp can be a problem as it reduces disinfection efficiency. The tube modules should therefore be easy to extract for cleaning. Electrical safety is another area to consider, particularly where the tube connections are below the waterline.

UV lamps do not have an indefinite life and must be replaced after a certain period of operation. Each bank or module of tubes is normally equipped with an elapsed time meter to automatically signal the operator when replacement is due. In addition a monitoring system reading the UV output should be installed within a lamp cluster to ensure the performance is not deteriorating as a result of slime buildup. Tube failure should also be signalled.

Flow rates past the tubes must be carefully controlled in order to maximize the disinfection efficiency. This can be done electrically by sensor controlled sluice gates, or hydraulically, for example by a system of weirs. Cold weather should not harm a properly designed UV system providing that ice is kept away from the lamps. As the system is not required over the winter period anyway, the simple expedient is to drain the channels containing the lamps.

11.8 Approximate Costs

Comparative costs of chlorine, ozone and UV disinfection methods are set out below and in Figure 3. We caution that these are order of magnitude only and that actual costs will depend on circumstances.

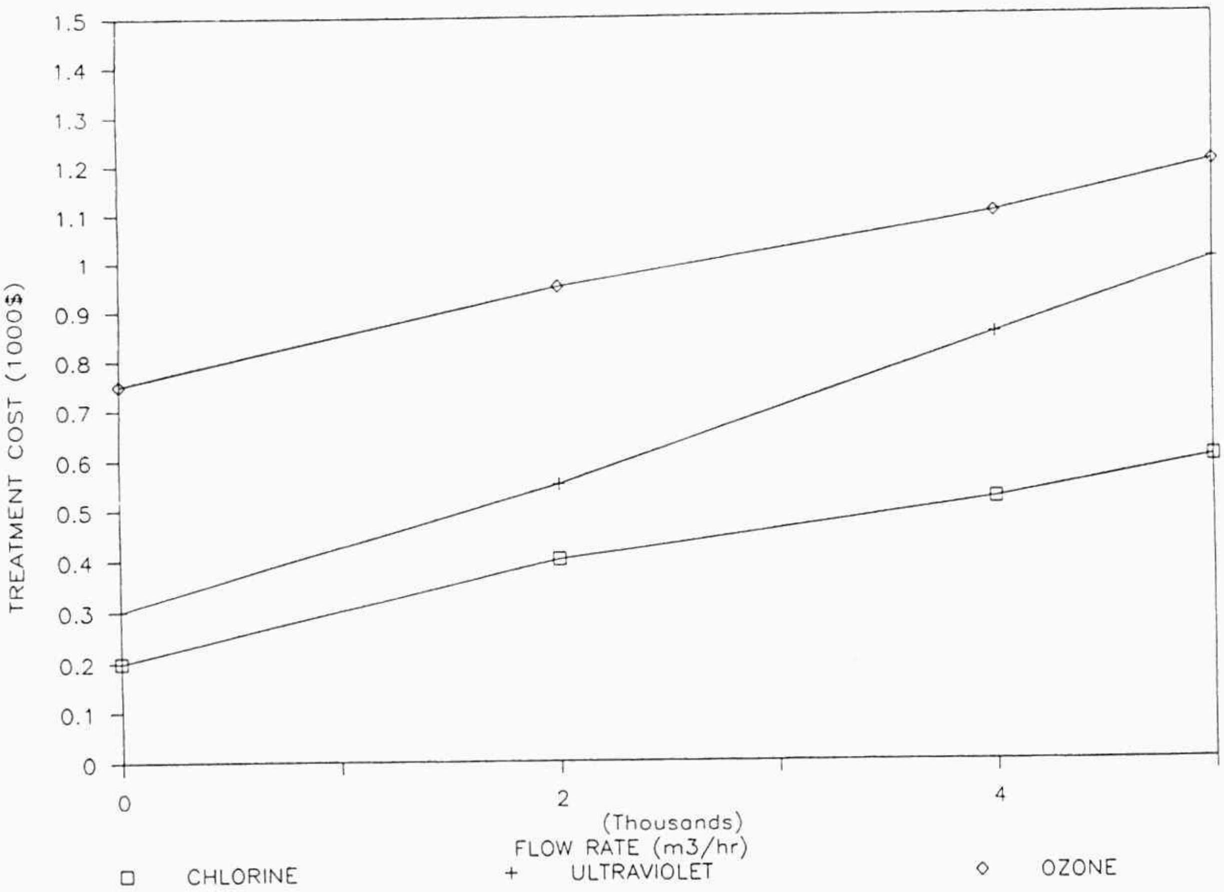

Figure 3: Cost Curve for Ultraviolet Disinfection

	Release Rate 2000 m^3/h	Release Rate 4000 m^3/h
Chlorination/Dechlorination		
Equipment:	$100 000.	$120 000.
Contact Chamber:	$200 000.	$300 000.
Building:	$100 000.	$100 000.
TOTAL CAPITAL COST:	$400 000.*	$520 000.*
Annual Operating Cost:	$10 000.	$20 000.
*Capital costs excludes re-aeration		
Ozonation		
Equipment:	$750 000.	$900 000.
Contact Tank:	included	included
Control Building:	$200 000.	$200 000.
TOTAL CAPITAL COST:	$950 000.	$1100 000.
Annual Operating Cost:	$70 000.	$110 000.
Ultraviolet Radiation		
Equipment:	$350 000.	$550 000.
Civil Works:	$200 000.	$300 000.
Control Cabinet:	included	included
TOTAL CAPITAL COST:	$550 000.	$850 000.
Annual Operating Cost:	$10 000.	$20 000.

NB: The operating costs noted above include only for power and consumables. No allowance is made for labour expenses.

11.9 Summary

Of the contaminants included in urban runoff including suspended solids, fecal bacteria, nutrients, metals, synthetic organic chemicals, and biochemical oxygen demand, the public has associated water pollution with the closing of beaches. The main parameter used to describe water quality is fecal coliforms. Historically, the treatment of stormwater runoff has involved construction of wet ponds to provide hold up time for settling of solids to improve the SS and BOD characteristics of the runoff. A side benefit has been a reduction in bacterial densities through settling and decay processes.

Since such technologies are not capable of achieving the desired water quality in a practical way, disinfection is necessary in some cases.

This paper has reviewed the desired benefits and possible problems associated with the disinfection of stormwater. It has focused upon evaluation of chlorination, ozonation, and ultraviolet treatment because despite these techniques being successful in water treatment and wastewater treatment plants, two questions still remain:

1. Will these techniques be successful for stormwater?
2. What additional constraints are posed to a stormwater application by receiving water ecosystem considerations?

The following issues in the design of disinfection systems for stormwater management were investigated in this paper:

- the wide flow variance compared to wastewater application;
- high suspended solids content and its shielding effect on disinfection;
- the use of coliform counts as a measure of pollution, and alternative possibilities;
- bacterial regrowth in the receiving waters;
- how disinfection works;
- the state of disinfection technology;
- the effects of chlorinated by-products on the natural environment; and
- capital and operating costs.

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CHAPTER 12

Cost and Maintenance Considerations For Various Structural Best Management Practices

David E. Maunder

ABSTRACT

Engineers, when designing facilities for protecting the environment often neglect to consider the maintenance and operation aspects. As a result, the proposed facility may function poorly, or in the long run, may cost significantly more than is necessary.

This paper discusses several of the design considerations which impact the operation and maintenance of several types of facilities (or BMPs), based upon a review of the operating and maintenance experience of several cities. The three specific BMPs examined are wet ponds, infiltration trenches, and infiltration basins. Cost estimates for various operation and maintenance activities are also provided.

12.1 Introduction

This paper presents information with respect to operation and maintenance considerations for various structural Best Management Practices (BMPs). Cost estimates for operation and maintenance of the facilities are also given. Several types of facilities were considered. These include:

i) wet ponds;
ii) infiltration basins; and
iii) infiltration trenches.

A majority of the information gathered was obtained through discussions with individuals responsible for maintaining the BMPs. Data were gathered from various municipalities within Canada, from various agencies within the United States and from Schueler (1987).

12.2 Wet Ponds

Several potential problems were identified for operating and maintaining wet ponds. These include:

i) maintaining a static water level;
ii) siltation;
iii) stability of the inlet/outlet devices;
iv) algae and weed control;
v) trash and debris collection;
vi) erosion due to wave action;
vii) safety;
viii) liability;
ix) mosquitos;
x) thermal stratification affecting fisheries;
xi) thermal heating impacting a resident cold water fishery in downstream waters; and
xii) private/public frontage.

In order to control or minimize these potential concerns various municipalities have established a prescribed program for maintaining the facilities. The maintenance activities may be divided into two categories, i.e.:

i) routine; and
ii) non routine maintenance.

12.2.1 Routine Maintenance

Several activities are included under routine maintenance including mowing and inspections.

The universal routine maintenance practice is grass cutting. Generally grass cutting is required 5 to 10 times per year and usually accounts for the largest cost component.

Periodic inspections are also required. The inspection programs varied and included:

- visual inspections to identify sediment buildup;
- inspection of the inlet/outlet devices after major storms (for debris buildup or stability);
- inspection of the spillway for stability (after major storm events);
- periodic checks for growth of algae or bullrushes;
- inspections for sloughing of banks after windy periods;
- inspection/maintenance of soggy/weedy areas conducive to mosquito growth; and
- collection/removal of debris, litter and floatables.

12.2.2 Non-Routine Maintenance

Non routine maintenance activities include the following:

1. Structural Stability Check

An inspection is required to ensure that spillway is intact, to establish whether or not the emergency spillway was utilized after flood flows and to carry out any necessary repairs. Care was generally taken to closely inspect the impervious/pervious interface of the spillway to ensure structural stability.

2. Shoreline Protection

In many instances the maintenance crews had concerns and felt repairs were necessary to maintain the water/land interface. This was usually attributed to a fluctuating water level which resulted in areas which were bare and not pleasing from an aesthetic perspective.

In several facilities in Winnipeg, a stone (or rip rap) interface was used. However, weed growth between the stones resulted in ongoing maintenance considerations.

In large ponds wave action occasionally caused sloughing of steep banks.

Many municipalities have overcome the above mentioned problems by using:

i) armour stone;
ii) plantings of emergent-submergent vegetation which can accommodate fluctuating water levels; or
iii) soil - cement mixtures.

3. Algae and Weed Control

Algae and weed growth was recognized as a significant problem in many areas. Several cities have tried chemical treatment to control growth (simazine or cutetrin). However, additional concerns with respect to toxicity of the chemicals were raised by various individuals, and are leading to evaluating alternatives.

The City of Winnipeg is currently experimenting with one alternative involving growing bullrushes to take up nutrients and then harvesting of bullrushes.

4. Mosquito Control

Few agencies had concerns with respect to mosquitos. Many individuals felt that the introduction of a fish species to feed on the mosquito larvae seemed to control the problem.

5. Dredging

It was generally recognized that dredging was required to maintain the capacity of the pond or lake. However, few municipalities seemed to know how frequently the facility should be dredged. Estimates of sediment accumulation ranged from 1 to 5 cm per year.

The frequency of dredging varied from annually to not yet being required. Many facilities had been in place for over a decade and had not been dredged. However, the individuals questioned were unsure as to whether the capacity of the facility had been reduced.

A general comment which was frequently made was that the rate of sediment accumulation decreased substantially once the upstream lands were fully developed.

6. Ongoing Monitoring

Few municipalities carried out monitoring programs to define whether the facility met the design criteria.

12.3 Programs of Specific Cities

A brief overview of the operation and maintenance practices of several specific municipalities and/or jurisdictional agencies is presented in this section.

(i) City of Winnipeg (53 facilities)

- no dredging to date, several facilities 15 years old - yearly accumulation up to 20 mm
- bullrushes harvested (tilled into high nutrient soil) - accumulation 4-12 tonnes/ha
- cutetrin used for algae/weed control
- no mosquito problem
- stone interface biggest problem
- 3 man crew maintains the facilities

Operations and Maintenance Costs

Salary	$83,000
Services/lights/power	26,000
Easements	1,500
Vehicle Rental	7,000
Chemicals	25,000
Miscellaneous Supplies	17,000
Harvesting	40,000
	$ 199,500 or $1,700/ha

These costs exclude:

Grass cutting
Replacement of Interface (estimate $5,500,000)
Dredging
Fountain Maintenance (estimate $300,000).

(ii) Westlake Lake (California)

Large facility primarily recreational - 55 Ha

Expenses:

Salaries	$ 115,000
Chemicals	27,000
Repairs	32,000
Utilities	12,000
Trash Removal	13,000

Legal	3,000
Lab Samples	22,000
Insurance	6,000
Other	30,000
	$ 260,000 or $4,200/Ha

(iii) Washington D.C. Area Ponds (T. Schueler Personal communication)

- Routine and Non Routine maintenance estimated at 3 to 5 % per year
- Dredging $ 5-10/Yd^3 (On site)
  $15-25/Yd^3 (Off site)
- Dredging required every 5-20 years.

(iv) City of Nepean
Primary Cost Components include:
i) Grass Cutting
ii) Daily Check (Drive-by) to ensure outlet structure is functional
Ponds not dredged last 4-5 years
Sediment accumulation 20-25 mm/Yr, (reduces as development completed)
Estimated Cost $4,000-5,000/Pond/year.

12.4 Infiltration Basins

Discussions were held with various individuals within the States of Maryland, Delaware and Washington. Many individuals expressed concern with respect to the long term viability of infiltration basins. Three major concerns were raised:

i) biological/chemical sealing of the surface;
ii) compaction of soil during construction due to heavy equipment being used;
iii) an insufficient number of borehole samples before construction. The borehole design used did not identify a lower layer of soil which is relatively non-permeable, and hence led to basin failure as an infiltration facility.

The bottom line seemed to be that over 50 percent of the existing facilities did not function adequately. Recommendations included more detailed borehole sampling and a better design of the surface drainage (e.g. continuous tilling or installation of subdrain and granular material).

An overview summary of cost estimates were not available from these discussions. Plausible cost estimates are given in MMM (1991).

12.5 Infiltration Trenches

There are many types of infiltration trenches commonly in use within the United States. Infiltration trenches are frequently used in conjunction with other BMP's, i.e. dry ponds, wet ponds and sediment traps.

Several concerns were brought out. These include:

i) the requirement for providing a sediment trap upstream;
ii) the protection of the infiltration trench during construction, due to silting;
iii) ensuring that borehole samples adequately define the soils.

Other limited information was available with respect to anticipated lifespan or operation and maintenance costs.

Several recommendations were made with respect to the design of future facilities. These include:

i) keeping the facility off of private property;
ii) providing a sediment facility to trap sediments and buffer strip upstream;
iii) selecting filter fabric carefully;
iv) taking borehole samples at exact location of proposed construction; and
v) providing an inspection well.

12.6 Conclusions

BMP facilities may function poorly, or in the long run, may cost significantly more than is necessary, because designers often neglect to consider the maintenance and operation aspects. This paper discussed several of the design considerations which impact the operation and maintenance of several types of facilities (or BMPs). In addition, a review of operation and maintenance practices for several BMPs within various municipalities was addressed.

Considerable background information is available with respect to operation and maintenance of wet ponds. The information generally indicates that operation and maintenance costs are in the range of $2,000 - $3,000 per year, assuming that the facility was reasonably designed. These estimates are similar to those for maintaining a dry pond or park area.

For infiltration devices less detailed information is available. However, recommendations were given by various professionals with respect to items to be considered in designing the facilities, such that operation and maintenance costs are minimized.

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CHAPTER 13

Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Government

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ABSTRACT

This paper reviews the major impacts to streams associated with urban land development. The key role of watershed imperviousness in determining the severity of impacts to stream hydrology, geomorphology, water quality and ecology are noted. Next, the paper outlines a comprehensive stream protection strategy for local governments to mitigate the adverse impacts of development, drawing from lessons learned over two decades of experience in the Washington, D.C. metropolitan area. Components include watershed master planning, development restrictions, environmental site-planning, construction sediment controls, urban stormwater runoff management and stream restoration programs. The paper identifies critical features that should be incorporated into the stream protection strategy.

13.1 Introduction

Urban streams are arguably the most extensively degraded and disturbed aquatic system in North America. In general, stream systems tend to reflect the character of the watershed in which they drain. Given the massive physical conversion in a watershed that accompanies urbanization, the degraded nature of urban streams is not surprising.

Over the last two decades, substantial evidence has accumulated regarding the pervasive impacts of urbanization on stream hydrology, geomorphology, water quality, habitat and ecology (Table 1). In response, local governments within the rapidly growing Washington Metropolitan area have developed an increasing number of stringent measures to mitigate the impact of new development on streams. The effectiveness of these measures has varied considerably, in large part because they have not been applied in a coordinated and comprehensive manner.

TABLE 1: MAJOR STREAM IMPACTS CAUSED BY URBANIZATION

Changes in Urban Stream Hydrology

Increase in Magnitude and Frequency of Severe Floods
Increased Frequency of Erosive Bankfull Floods
Increase in Annual Volume of Surface Runoff
More Rapid Stream Velocities
Decrease in Dry-Weather Baseflow on Stream

Changes in Urban Stream Morphology

Stream Channel Widening and Downcutting
Increased Streambank Erosion
Shifting Bars of Coarse-Grained Sediments
Elimination of Pool/Riffle Structure
Imbedding of Stream Sediments
Stream Relocation/Enclosure or Channelization
Stream Crossing From Fish Barriers

Changes in Urban Stream Water Quality

Massive Pulse of Sediment During Construction Stage
Increased Washoff of Pollutants
Nutrient Enrichment Leads to Benthic Algal Growth
Bacterial Contamination During Dry and Wet Weather
Increase in Organic Carbon Loads
Higher Levels of Toxics, Trace Metals and Hydrocarbons
Water Temperature Increase
Trash/Debris Jams

Changes in Stream Habitat and Ecology

Shift from External to Internal Stream Production
Reduction in Diversity of Aquatic Insects
Reduction in Diversity and Abundance of Fish
Destruction of Wetlands, Riparian Buffers, and Springs

This paper outlines a watershed approach for urban stream protection that incorporates the most useful and effective planning and engineering techniques that have evolved in the Washington metropolitan area. The stream protection strategy is based on comprehensive and continuous regulation of the development process from the master planning stage until it is ultimately realized.

13.2 The Impacts of Urbanization on Streams

Urbanization has a profound influence on stream quality. The extent of this influence is obvious when an urban stream is compared to another in a rural or natural watershed. Impacts in urban streams can be loosely grouped into four categories: changes to stream hydrology, geomorphology, water quality and aquatic ecology. The intensity of the impacts is typically a function of the intensity of urbanization. A convenient measure of development intensity is the percentage of watershed area devoted to impervious surfaces (roads, parking lots, rooftops, sidewalks, compacted fill, etc.). Operationally, watershed imperviousness can be simply defined as the fraction of watershed area that is unvegetated.

13.2.1 Changes in Stream Hydrology

The hydrology of urban streams changes immediately in response to site clearing. The natural runoff storage capacity is quickly lost with the removal of the protective canopy of trees, the grading of natural depressions, and the elimination of spongy topsoil and wetland areas. As the soil is further compacted and resurfaced by impervious materials, rainfall can no longer percolate into the soil, and is rapidly and effectively converted into surface runoff. Thus, the net effect of development is to dramatically change the hydrologic regime of the urban streams such that:

- The magnitude and frequency of severe flood events increases. In extremely developed watersheds (impervious >50%), the post-development peak discharge rate may increase by a factor of five from the pre-development rate. These more severe floods reshape the dimensions of the stream channel and its associated floodplain.

In addition, watershed development increases the frequency of bankfull and sub-bankfull flooding events. Bankfull floods are defined as floods that completely fill the stream channel to the top of its banks, but do not spill over into the floodplain. Schueler (1987) estimates that the number of bankfull floods increases from one every other year (prior to development) to over five each year (for a 50% impervious watershed). In practical terms, this means that a short but intense summer thunderstorm that had scarcely raised water levels prior to development may turn an urban stream into raging torrent. The greater number of bankfull floods subject the stream channel to continual disturbance by channel scour and erosion.

- <u>More of the stream's annual flow is delivered as surface storm runoff rather than baseflow or interflow.</u> In natural undeveloped watersheds, anywhere from 5 to 15% of the annual streamflow is delivered during storm events, depending on watershed vegetative cover, soils and geology. By contrast, in developed watersheds, the majority of annual streamflow occurs as surface runoff. As a general rule, the amount of storm runoff increases in direct proportion to the amount of watershed imperviousness. For example, surface runoff typically comprises half the annual streamflow in a watershed that is 50% imperviousness (Schueler, 1987).

  Consequently, the amount of baseflow and interflow available to support streamflow during extended periods of dry weather is greatly reduced. In smaller headwater streams, the reduction in dry weather flow can cause a perennial stream to become seasonally dry. In larger urban streams, the reduced dry weather flow can significantly restrict the wetted perimeter of the stream that is available for aquatic habitat.

- <u>The velocity of flow during storms becomes more rapid.</u> This is due to the combined effect of greater discharge, rapid time of concentration, and smoother hydraulic surfaces. In a 50% impervious watershed, post-development runoff velocities exceed thresholds for erosivity, requiring channel protection measures or even stream enclosure. In addition, streamflow becomes extremely flashy, with sudden and sharp increases in discharge followed by an equally abrupt return to pre-storm discharge levels.

13.2.2 Changes in Urban Stream Morphology

Stream channels in urban areas must respond and adjust to the altered hydrologic regime that accompanies urbanization. The severity and extent of stream adjustment is a function of the degree of watershed imperviousness, and can be summarized as follows:

- The primary adjustments to the increased stormflow is channel widening, and to a lesser extent, down-cutting. Stream channels in moderately developed watersheds may become four times wider than after development (Schueler, 1987). The channel widening process is primarily accomplished by lateral cutting of the streambanks. As a consequence, the riparian zone adjacent to the channel is severely disturbed by undercutting, tree-fall and slumping.

- Sediment loads to the stream increase sharply due to streambank erosion and upland construction site runoff. The coarser grained sediments are deposited in the new wider channels and may reside there for years until the stream can export them from the watershed. Much of the sediment remains in temporary storage, in the form of constantly shifting sandbars and silt deposits. The shifting bars often accelerate the streambank erosion process by deflecting runoff into sensitive bank areas.

- Together, the massive sediment load and channel widening produce a major change in the morphology of urban streams. The series of pools and riffles so characteristic of natural streams is eliminated, as the gradient of the stream adjusts to accommodate the frequent floods. In addition, the depth of flow in the channel becomes shallower and more uniform during dry weather periods. The loss of pool and riffle structure in urban streams greatly reduces the availability and diversity of habitat for the aquatic community.

- The nature of the streambed is also modified by the urbanization process. Typically, the grain size of the channel sediments shifts from coarse grained particles towards a mixture of fine and coarse grained particles. This results in a phenomena known as imbedding, whereby sand, silt and even clay fill up the interstitial voids between larger cobbles and gravels. Imbedding reduces the circulation of water, organic matter and oxygen to the filter-feeding aquatic insects that live among and under the bed sediments. These insects are the basic

foundation of the stream food chain. In addition, imbedding of the stream sharply limits the quality and availability of fish spawning areas, particularly for trout.

- In intensively urbanized areas, many streams are totally modified by man to "improve" drainage and reduce flooding risks. Headwater streams tend to suffer disproportionately from enclosure. Quite simply, the headwater stream is entirely destroyed, and is replaced by an underground network of storm drain pipes. In the past, larger urban streams have been engineered and channelized to more efficiently and safely convey floodwaters. Although large-scale stream channelization is now discouraged, some form of future channel "improvement" is inevitable if development is allowed within the post-development floodplain.

- Another inevitable consequence of urbanization are stream crossings by roads and pipelines. These structures must be heavily armored to withstand the down-cutting power of stormwater. Many engineering techniques utilized for this purpose (drop structures, gabion mats, culverts, etc.) create barriers to the migration of both resident and anadromous fish. Even a six inch drop can block the upstream areas for certain fish species.

13.2.3 Changes in Stream Water Quality

During the initial phase of development, an urban stream receives a massive pulse of sediment eroded from upland construction sites. Unless erosion and sediment controls are used, sediment loads and turbidity levels increase by two to three orders of magnitude from predevelopment levels. Sediment levels often decline once upland development stabilizes but never return to pre-development levels, because of increased streambank erosion.

Once construction is complete, the dominant pathway of pollutants to a stream is the washoff of accumulated deposits from impervious areas during storms (MWCOG, 1983). Substantial quantities of nitrogen, phosphorus, carbon, solids and trace metals are deposited on urban surfaces as both dry and wet atmospheric deposition, and are rapidly and directly conveyed to the stream via storm drains. Other non-atmospheric sources of pollutant accumulation are also important, such as pet droppings, leaf litter, vehicle leakage and deterioration of urban surfaces.

In general, the pollutant levels in urban streams are one to two orders of magnitude greater than those reported in forested watersheds. The degree of pollutant loading has been shown to be a direct function of the percentage of watershed imperviousness (Schueler, 1987). In urban streams, the higher pollutant loadings translate into water quality problems, such as:

- Nutrient enrichment. Nitrogen and phosphorus concentrations in urban runoff stimulate excessive algal growth, particularly in shallow, unshaded stream reaches. most of algal growth is benthic in nature, attaching on rocks or growing within the slime coating that surrounds rock surfaces in urban streams.

- Bacterial contamination. Bacterial levels in urban streams routinely exceed U.S. Public Health standards during both wet and dry weather, rendering them unsuitable for water contact recreation. The sources of bacterial contamination are complex, but include the washoff of pet faeces and leakage from sanitary sewer lines.

- Organic matter loads. Loads of organic matter delivered during storm events are equivalent in strength to primary wastewater effluent. When the organic matter eventually settles out in slower moving lakes and estuaries, the oxygen demand exerted during their decomposition depletes oxygen from the water column.

- Toxic compounds. A large number of potentially toxic compounds are routinely detected in urban stormwater. These include trace metals (lead, zinc, copper, and cadmium), pesticides and hydrocarbons (derived from oil/grease and gasoline runoff), among others. While the duration of exposure to these toxic chemicals is limited during storms, they tend to accumulate in benthal sediments of urban streams, lakes and estuaries. Not much is known about the individual or collective toxicity of these compounds to the stream community. However, some degree of impact is likely, given the consistently poor aquatic diversity noted in these ecosystems.

- Temperature Increase. Impervious areas act as heat collectors. Heat is then imparted to stormwater runoff as it passes over the imperviousness. Recent data indicate that intensive urbanization can increase stream water temperatures by as much as 5 to 10 degrees Celsius during storms (Galli, 1990). A similar

temperature increase may occur during dry weather periods, if a stream's protective riparian forest canopy has been eliminated, or if ponds and lakes are created upstream.

The thermal loading severely disrupts aquatic organisms that have finely-tuned temperature limits. Cold-water organisms such as trout and stoneflies are particularly sensitive, and often become locally extinct in intensively developed streams.

- Trash/debris. A conspicuous and diagnostic feature of urban streams is the presence of large debris jams in the stream and floodplain, composed of litter, leaves, and trash that has washed through the storm drain system. The debris jams greatly detract from the scenic appearance of the stream.

13.2.4 Changes in Stream Habitat and Ecology

The ecology of urban streams is shaped and molded by the extreme shifts in hydrology, geomorphology and water quality that accompany the development process.

The stresses on the aquatic community of urban streams are both subtle and profound, and are often manifested in the following ways.

- Shift from external to internal stream production. In natural streams, the primary energy source driving the entire aquatic community is the import and decomposition of terrestrial detritus, namely leaf litter and woody debris. However, in many urban streams, internal benthic algal production becomes a major energy source supporting the aquatic community, due to the combined effect of increased light penetration and nutrients (and the rapid washout of terrestrial detritus through the stream system). This shift is often manifested in changes in the mix of species found in the stream community. For example, environmental conditions are more favourable for species that graze algae from rocks (e.g., snails) than for species that shred leaves or filter coarse grained detritus (caddisfiles, stone flies, etc.).

- Reduction in Diversity in the Stream Community. The cumulative impact of the loss of habitat structure (pools/riffles), the imbedding of the streambed, greater flooding frequency, higher water temperatures, extreme turbidity, lower dry weather flows, eutrophication, and toxic pollutants conspire to greatly reduce the diversity and richness of the urban stream community. In intensively developed areas, streams support only a fraction of the fish and macroinvertebrates that exist in natural reference streams.

- Destruction of Freshwater Wetlands, Riparian Buffers and Springs. In the past decade, it has been necessary to abandon the notion that a stream ecosystem is defined solely by its channels. It is now understood that a stream ecosystem extends to include the extensive freshwater wetlands, floodplains, riparian buffers, seeps, springs, and ephermal channels that are linked to the stream. These areas contribute, in varying ways, many of the ecological functions and processes upon which the stream community depends. Unfortunately, these areas are frequently destroyed or altered during by indiscriminate clearing and grading during the construction phase of development.

13.3 Comprehensive Urban Storm Protection Strategy

For the past two decades, governments in the Washington metropolitan area have attempted to deal with the complex impacts of urban growth on streams by creating an equally complex series of regulations, programs and controls on the urban development process. The success of these measures in mitigating the impacts on streams, however, has been less than anticipated. The primary reason has been individual measures are developed in response to a single impact that occurs during a unique phase of the development cycle. Until recently, little effort has been made to craft and a comprehensive stream protection strategy throughout the entire development cycle, from development of watershed master plans to the ultimate realization of that development.

What follows is an attempt to outline the elements of an effective local stream protection strategy that can minimize the impacts of growth on urban streams. It is hoped that this strategy can be further refined and adjusted to aid local governments in developing effect programs to maintain stream quality.

The comprehensive stream protection strategy has six primary components that roughly relate to various stages of the development cycle (Table 2). They are:

TABLE 2: SIX ELEMENTS OF A COMPREHENSIVE STREAM PROTECTION STRATEGY

1. **Watershed Master Planning**

   Evaluation and Mapping of Stream Resources
   Designating Stream Quality Classes
   Zoning to Protect Unique and Sensitive Stream Systems
   Evaluation of Adequacy of Current Stream Protection Programs
   Regional Stormwater Management Planning

2. **Adoption of General Development Restrictions**

   Variable-width Stream Buffer Requirements
   Floodplain Development Restrictions
   Steep Slope Restrictions
   Non-tidal Wetland Protection
   Protection of Environmentally Sensitive Areas
   Upland and Riparian Tree Cover Preservation Requirements
   Waterway Disturbance Limitations
   Community Open-Space Requirements

3. **Environmental Site Planning Techniques**

   Cluster Development
   Transferable Development Rights
   Planned Unit Developments
   Flexible Road Width Requirements
   Fingerprinting of Site Layout

4. **Sediment and Erosion Control During Construction**

   Limit Area and Time of Construction Disturbance
   Immediate Vegetative Stabilization of Disturbed Areas
   Use of Super-basins for Sediment Control
   Frequent Inspection of Erosion and Sediment Controls
   Strong Civil Enforcement Authority for Violations

TABLE 2: SIX ELEMENTS OF A COMPREHENSIVE STREAM PROTECTION STRATEGY

5. Urban Stormwater Best Management Practices

BMP Performance and Maintenance Criteria
First Flush Treatment Requirements
Use of Extended Detention Wet Pond Marsh Systems
Use of Infiltration Systems with Pretreatment
BMP Landscaping, Safety and Appearance Guidelines
Careful Environmental Review of Urban BMPs
Strong Local BMP Plan Review and Inspection
Public BMP Maintenance Responsibility and Financing

6. Community Stream Restoration Programs

Long-term Stream Trends Monitoring
Watershed Assessment of Restoration Opportunities
Retrofitting of Older Urban BMPs
Construction of New Urban BMPs
Riparian and Upland Reforestation Programs
Instream Fish Habitat Improvements
Urban Wetland Restoration and Creation
Removal of Fish Barriers
Urban Stream Stewardship

1. Watershed Master Planning.
2. General Development Restrictions.
3. Environmental Site-Planning Techniques.
4. Sediment and Erosion Control During Construction.
5. Urban Stormwater Best Management Practices.
6. Community Stream Restoration Programs.

Key features of these six components are summarized in Table 2. They are described in more detail in succeeding sections.

13.3.1 Watershed Master Planning

The future quality of an urban stream is fundamentally determined by the broad land-use decisions made by a community. It is therefore essential that the impact of future development on streams be assessed during the master planning process. The appropriate planning unit for this assessment is the watershed. The location and intensity of future development within the watershed should be carefully examined from the following perspectives:

- Evaluating Stream Resources. The first step in the planning process is to survey the stream resources within a jurisdiction to obtain basic information on their use, quality and value. It is also useful to survey and delineate floodplains, wetlands and other environmentally sensitive areas during this stage.

- Designating Stream Quality Classes. The next step is to rank and prioritize the stream systems within a locality, based on the stream resource surveys. Stream use classes are designated to set forth the appropriate targets for stream quality that will be maintained during the development process. Unique areas, such as cold-water trout streams, warmer water stream fisheries, scenic reaches, and extensive stream/wetland/floodplain complexes should be targeted for special protection. The upland watersheds draining to these unique areas can only be protected through a combination of low density zoning, open space preservation and stream valley park acquisition (as well as strict sub-division, sediment and stormwater controls during low density development process). Based on experience in the Washington area, it is almost impossible to maintain the quality of these unique systems if upland watershed imperviousness exceeds 10 to 15 percent.

- Evaluating the Adequacy of Stream Protection Programs. The watershed master planning stage provides an excellent opportunity for a community to critically review the adequacy its stream protection measures before development begins. This requires a thorough analysis review of whether the community has the authority, criteria, review staff and enforcement capability to maintain its stream protection programs in the areas of environmental sub-division review, construction sediment controls, stormwater management and stream restoration. If a community is unwilling to commit the financial and staff resources to stream protection programs, watershed master planning becomes a meaningless exercise.

- Regional Stormwater Management Planning. An important component of watershed master planning is the use of hydrologic and hydraulic simulation models to project a stream's future hydrologic regime. Models are a useful (but not sufficient) means of evaluating the impact of future development scenarios on stream quality. The models can also be used to identify the most effective locations in the watershed to construct regional stormwater management facilities, thereby enabling a community to acquire the sites to construct regional facilities before development begins.

13.3.2 Development Restrictions

The second phase in a community stream protection plan is the adoption of a comprehensive and integrated set of environmental restrictions to govern the development process. The greatest level of stream protection is afforded when a single development ordinance is adopted by a community, and administered by a single planning authority. In short, the ordinance mandates a minimum level of environmental site planning during development, and includes, but is not limited to, the following items. Several innovative local regulations from the Washington metropolitan area are referenced.

- Stream Buffer Requirement. Development is not allowed within a variable width buffer strip on each side of ephermal and perennial stream channels. The minimum width of the buffer strip is 50 feet for low-order headwater streams, but expands to as much as 200 feet in larger streams (Baltimore County, 1989). The stream buffer further expands to include floodplains, steep slopes, wetlands and open space areas to form a contiguous system, according to prescribed rules.

- Floodplain Restrictions. No development is allowed within the boundaries of the post-development 100 year floodplain, as designated in the watershed masterplan. This eliminates the need for future flood protection measures for these properties, and forms an essential component of the stream buffer system.

- Steep Slope Restriction. No clearing and grading is permitted on slopes in excess of 25% (MNCCPC, 1984). These areas may be tied into the stream buffer system, or may exist as isolated open space reserves.

- Non-tidal Wetland Protection. No development is permitted within non-tidal wetland areas and a perimeter buffer area (25 to 50 feet). In many cases, the establishment of the stream buffer system will have already protected these important areas (Maryland Department of Natural Resources, 1989).

- Protection of Environmental Sensitive Areas. Development is not allowed within unique habitat areas and plant communities and protective perimeter buffers, as identified in the watershed master planning study (MD CAC, 1987). It is critically important to provide corridors from upland environmentally sensitive areas to the stream buffer system.

- Upland and Riparian Tree Cover Requirements. An allotted percentage of upland pre-development tree cover must be maintained after site development (Prince George's County DER< 1989). In addition, the riparian tree cover (which should be entirely contained within the stream buffer system) must also be retained, or reforested (if no tree cover currently exists). Where possible, tree-save areas should be lumped into large blocks tied into the buffer system rather than small and isolated stands. Numerous studies have confirmed that local wildlife diversity cannot be maintained in small islands of trees surrounded by urbanization (Hench, 1986).

- Waterway Disturbance Permits. Certain forms of development such as roads and utilities, must, by their very nature, cross through the stream buffer system and thereby reduce its effectiveness. Linear developments must be closely scrutinized to locate them in the narrowest portions of the buffer system, and ensure that they do not form barriers to either fish or riparian migration. In addition, the time "window" that the stream and buffer system can be disturbed by construction activity should be limited to exclude critical fish spawning seasons.

- Community Open Space Requirements. Once the stream buffer system has been delineated, the developer is still required to preserve an additional percentage of open space at the site to accommodate the residents' future requirements for parks, playgrounds, ball fields, and other community needs. If an acceptable amount of community open space is not reserved for this purpose, it is extremely difficult to maintain the integrity of the stream buffer in the future.

13.3.3 Environmental Site Planning at the Site Level

Significant opportunities still remain to protect streams during the site planning stage. The major objective is to minimize the total amount of site imperviousness at the site, and cluster development into centralized areas where stormwater can be effectively treated. The best tools at this stage are incentive methods such as transferable development rights, cluster zoning, site "fingerprinting", planned unit development and flexible site and road width layout. An excellent review of how these site planning methods an be applied to protect streams is contained in Yaro *et al.* (1988).

13.3.4 Erosion and Sediment Control During Construction

The fourth component of an effective stream protection strategy is to reduce the massive pulse of sediment that inevitably occur during the construction stage of development. To accomplish this goal, it is necessary to both minimize the degree of erosion within the construction site (Erosion Control) and to remove sediments borne in construction site runoff as they leave the site (Sediment Control). An excellent design manual of state-of-the-art erosion and sediment control techniques are the Maryland Standards and Specifications (MDE, 1990).

Several strategies have been shown to very effective in reducing downstream sediment concentrations during the construction phase. These include:

- Reduce the area and length of time that a site is cleared and graded. This reduces the potential for erosion and can be done by: (a) prohibiting clearing and grading from all post-development buffer zones at the site, (b) configuring the site plan to retain as much undisturbed open space as possible (e.g., such as

cluster zoning and the environmental site planning techniques noted earlier), and (c) phased construction sequencing to limit the amount of disturbed area exposed at any given time.

- Immediate vegetative stabilization of disturbed areas. Recent studies in the Washington metropolitan area indicate that the rapid establishment of a grass or mulch cover on cleared and graded areas construction sites can result in a six-fold reduction in downstream suspended sediment levels (Schueler and Lugbill, 1990).

- Use of "Super" sediment control basins. Super-basins have wet and dry storage equivalent to one-inch of sediment per acre of upland watershed area. If properly designed and maintained, super-basins can provide reliably high rates of sediment removal for most of the storms during the year (Schueler and Lugbill, 1990). Smaller, conventionally-designed sediment basins and sediment traps exhibit highly variable sediment removal rates, and are often overwhelmed during larger storms.

- Frequent on-site inspection of erosion and sediment controls. The landscape at a construction site often changes dramatically from week to week. Consequently, it is critically important that sediment inspectors visit the site at least every two weeks to ensure that the sediment control plan is working and that all control measures are being properly initiated and maintained. In particular, inspections should be concentrated during the latter stages of construction, when the sediment delivery potential from the site is at its highest.

- Provide sediment control inspectors with strong enforcement authority. This authority is needed to allow inspectors to direct contractors to promptly correct violations of the sediment control plan in the field. The best success has been enjoyed in communities where inspectors are empowered to issue automatic and costly civil fines for sediment control violations. These strong enforcement tools are critical in forcing construction contractors to make erosion and sediment control a part of their daily operations.

13.3.5 Urban Best Management Practices and Stormwater Control

The fifth component of an effective stream protection strategy are local requirements to install urban stormwater best management practices (BMPs) to control post-development stormwater runoff. Urban BMPs try to replicate the natural, pre-development hydrologic regime of a stream by infiltrating, retaining or detaining the increased quantity of urban stormwater produced by development. In addition, urban BMPs may partially reduce the increased load of pollutants generated from developed areas.

In recent years, major advances have been made in urban BMP planning and design. While a thorough discussion of current urban BMP techniques is outside the scope of this paper, several reviews are available on the subject (Schueler, 1987; MDE, 1983). In addition, area local governments have prepared model ordinances to implement effective urban stormwater programs (see, for example, Montgomery County (1985) and subsequent revisions).

Several important points should be kept in mind about urban BMPs. First, urban BMPs can never fully mitigate the wide spectrum of hydrologic and water quality impacts that accompany urbanization. That is, they can never compensate for poor watershed master planning, an inadequate stream buffer network or sloppy site planning. Second, urban BMPs are a simple technological solution to a complex problem, and in some cases may create as many environmental problems as they eliminate. For example, pond BMPs have been shown to increase water temperatures and stress cold-water organisms (Galli, 1990), to be a significant cause of destruction of freshwater wetlands, and represent a local interruption to the stream continuum. Similarly, infiltration BMPs may increase the risk of groundwater contamination and have a high rate of failure (MDE, 1986).

Third, urban BMPs are a significant feature of the community, and can become a locally unwanted land use (LULU), if careful attention is not paid to concerns such as landscaping, appearance, safety, stagnation, and maintenance. Finally, urban BMPs must be maintained if they are to continue to protect streams in the future. Communities must recognize, accept and finance the maintenance burden from stormwater management.

13.3.6 Stream Restoration Techniques

The final element of an effective stream protection strategy is a community stream restoration program. The primary purpose of stream restoration is to enhance the aquatic habitat and ecological functions of urban streams that has been lost or degraded during the urbanization process. In a sense, stream restoration programs are an attempt to fix the mistakes made during the development process. The best way to identify these mistakes is to look at the post-development stream from the perspective of a fish. That is, what are the dominant changes in the post-development stream that have contributed most to the decline of a healthy stream community?

- Long-term Stream Trends Monitoring. The first step is to conduct systematic biological surveys throughout the stream system to every five to ten years to identify reaches where the aquatic community has shown the greatest decline. These reaches indicate that some aspect of the stream protection effort has failed, and become the first candidates for stream restoration.

- Watershed Assessment of Restoration Opportunities. The second step is to walk the stream and its upland watershed to determine the dominant impacts that have degraded the aquatic community, and identify feasible opportunities for restoring stream habitat or water quality. Stream assessments are best done on one to ten square mile sub-watersheds, where a team of aquatic biologists and engineers can identify possible restoration opportunities within urban BMPs, the stream buffer network and the stream itself.

- Retrofitting of Urban BMPs. The best restoration opportunities often involve the improvement of existing urban BMPs. Unfortunately, many urban BMPs never achieve in the field what was hoped for at the drafting table. In addition, since urban BMP design is constantly changing and improving, most older urban BMPs do not have the pollutant removal capability of current designs (e.g., the dry stormwater management pond).

  These older urban BMPs offer great opportunities for retrofitting at relatively modest investment. Pond retrofitting has been the primary focus of restoration efforts in the Washington metropolitan area (Herson, 1989), and has typically involved converting older dry stormwater ponds into extended wet pond marsh systems.

- Construction of Additional Urban BMPs. In watersheds where development has occurred prior to the implementation of a community stream protection strategy, it is often necessary to retrofit new urban BMPs into the urban landscape. This is not an easy task, given the limited amount of space available. However, surveys have shown that acceptable sites can be found in a developed watershed, and that public land agencies will participate in a retrofit program, particularly if it is demonstrated that the proposed urban BMPs will improve the amenity value on those public lands (Galli and Herson, 1988, 1989). Innovative retrofit techniques are currently being developed for these areas, including the peat-sand filter (Galli, 1988), oil grit separator inlets (Shepp, 1989), and extended detention lake/wetland systems (Schueler and Helfrich, 1987).

- Riparian Reforestation Programs. A common problem encountered in urban streams is that the riparian stream buffer zone has been cleared. Fortunately, the buffer zone can be gradually reforested within a matter of years, through cooperative community tree planting programs at a relatively low cost. These volunteer programs have become extremely popular in the Washington area, and are most effective when local governments arrange the logistics, assemble the sites, and secure the plant stock, according to a long-term watershed plan.

- Upland Reforestation Programs. A useful method for reducing the adverse impact of watershed imperviousness on urban streams is to reforest upland areas. Quite simply, impervious areas are converted into pervious, forested areas. Again, a community reforestation program, that utilizes native tree species and citizen volunteers, is a useful tool. These programs have the additional benefits of increasing citizen awareness about environmental stewardship and improving the appearance of the urban landscape.

- Instream Fish Habitat Improvement. From the perspective of a fish, the dominant impact associated with urbanization is probably the degradation of stream habitat structure, most notably the loss of pools, riffles and clean spawning areas. These habitat features can be recreated within urban streams by adapting habitat improvement techniques developed by stream biologists to increase fish production in more natural stream systems. These techniques include the use of boulder and log deflectors, log drop structures, brush bundles, willow wattles, boulder placement and imbricated rip-rap. These stream

restoration techniques are being applied in several highly degraded stream reaches of the urbanized Anacostia watershed to test the hypothesis that an improvement in stream habitat can improve local fish diversity and abundance in urban streams (Galli, 1990).

- Urban Wetland Creation/Restoration. Despite recent regulatory protections, it is likely that most watersheds have lost, and will continue to lose, large areas of freshwater and tidal wetlands to the development process. This is because urban stormwater runoff exerts the same series of pervasive and adverse impacts to urban wetlands as it does to urban streams. It is therefore critical to actively restore and manage urban wetlands, rather than merely conserve them. Otherwise, the ecological value and functions of urban wetlands will gradually diminish over time. It is equally critical to create new urban stormwater wetland areas that partially substitute for the lost ecological functions of the destroyed or degraded wetland system.

  A series of urban wetland restoration and creation projects are currently being performed in the Anascotia River basin (Kumble, 1990). At present, the goal of these programs is to augment the total acreage and environmental function of urban wetlands at the scale of the sub-watershed.

- Identification and Removal of Fish Barriers. The urban network should be periodically surveyed to detect possible barriers to anadromous and resident fish migration. Fish barriers can be detected through systematic upstream/downstream fish collections at suspected structures during spring runs (Cummins, 1988), or in some cases, by visual surveys. In many cases, urban fish barriers are created by relatively low drop structures that can be rather easily modified to allow migration. In the Anacostia, simple and low cost modifications to two drop structures are planned that are expected to open up several miles of spawning habitat to anadromous fish (Cummins, 1989).

- Stream Stewardship. The foundation of effective community stream restoration programs are citizens that take an active and personal interest in maintaining urban stream quality. Local governments should recognize these individuals, and encourage them to adopt a stream and participate in streamwalks, tree-plantings and other volunteer programs. These urban stream stewards can also be of great

value in reporting oil spills, sediment control violations, pollution problems, and sewer overflows. Most of all, stewards can act as effective advocates for urban streams, which is critical in maintaining any public program.

13.3.7 Concluding Remarks

Protecting urban streams from development is obviously a difficult task. The six step strategy outlined in this paper requires an extensive commitment of knowledge, resources and staff on the part of a community. To be successful, a community must be willing to place the protection of urban streams on the same par with economic growth and the creation of urban infrastructure. If these conditions can be met, it is possible to mitigate the impact of development, and to maintain a quality stream system for the future generations that will live and work within them.

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CHAPTER 14

Municipal Implementation and Implications of Storm Water Quality Controls

M. A. Price and J. Tran

ABSTRACT

In the 70's and 80's, municipalities in Ontario have struggled to develop criteria and techniques for implementing stormwater management. For management and implementation of control of stormwater flow rates, the concepts of a watershed plan, a master drainage plan, and a drainage report (stage 1 and stage 2) are now widely accepted.

For management of stormwater quality, the concepts and methods of implementation are yet to be defined in a routine way.

This paper reviews the various provincial programs that a municipality can use to implement various quality related policies and guidelines which include: fisheries (MNR), Interim Stormwater Quality Control Guidelines (MOE/MNR), Erosion and Sedimentation Guideline (MOE) and Pollution Control Planning (MOE).

Then this paper reviews the implications of relevant case law. In the case of the City of Scarborough versus Scarborough Golf & Country Club, the City has been found liable. The implications of practising (or not practising) water quality control are addressed from the viewpoint of an urbanized municipality which has learned the hard way.

14.1 Introduction

The City of Scarborough is located on the north shore of Lake Ontario. It is one of the six municipalities that make up Metropolitan Toronto and is the seventh largest city in Canada. (Figure 1) with a population of close to 500,000. Scarborough is still growing

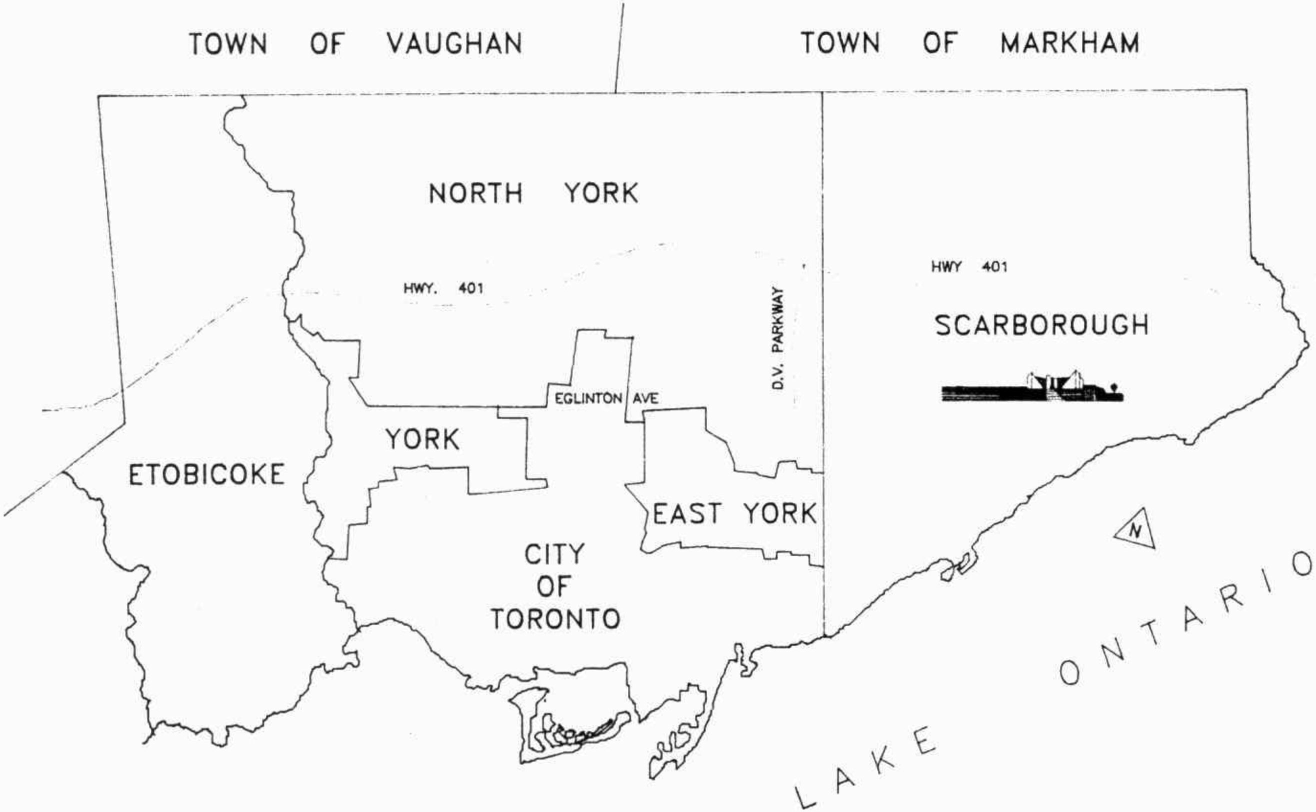

Figure 1: Municipalities of Metropolitan Toronto

and must deal with water quality problems from the tracts of land available for industrial, commercial and residential development. It must also deal with problems associated with existing developments which did not benefit from new methods of water quality protection and environmental enhancement.

This paper addresses issues related to implementation of storm water quality controls, as they affect a municipality such as the City of Scarborough.

14.2 Role of the Municipality

In the Scarborough area of the Province of Ontario, there are four levels of government with a role in water quality management. They are:

Federal (i.e. Environment Canada)
Provincial (i.e. M.O.E., M.N.R.)
Regional (i.e. Metropolitan Toronto)
and Local (i.e. City of Scarborough)

There is a clear distinction between each level of government. In terms of mandate, the local government is the most confusing. Local governments are called upon to deal with many varied issues including taxes, education, recreation, fisheries, solid waste collection and disposal on a daily basis. Yet most people are not aware of the role that a municipality, local or regional, plays in the implementation of storm water quality controls.

This lack of awareness is typified by a survey presented by a university professor at a recent workshop on non-point source pollution (NPS), on the perception of NPS. Those surveyed included nine (9) Conservation Authorities, nine (9) individuals from private consulting firms, one (1) individual from Environment Canada, two (2) from the Ministry of the Environment, one (1) from the Ministry of Agriculture and Food. Regional and local municipalities were not surveyed as it was felt that they have different "interests".

While it may be correct that not all municipalities have an interest in NPS, municipalities are expected to be responsible for the design, implementation, and maintenance of remedial measures oriented to controlling stormwater quality and probably to assume the

financial and other liability of these measures. Because of these responsibilities, municipalities should and must participate in policy-making decisions, direction and implementation of point and non-point pollution control, made at the provincial level.

The potential role that municipalities can have in improving environmental quality and the need for integration of the activities of different government agencies is illustrated in Figure 2 extracted from the "1987 Report on Great Lakes Water Quality". Figure 2 illustrates the major activities needed to improve environmental quality (across the figure) and the different Canadian and American governing bodies and citizens with a role to play. It is obvious that the municipalities along the Great Lakes can and will make a major difference.

14.3 Natural and Environmental Assets

As a growing urban municipality, Scarborough has many diversified natural and environmental assets which it is trying to preserve while permitting the "healthy growth" expected by citizens in the City. By assets, we mean "something of value", as defined by Webster's dictionary. A healthy fishery, parks and valleys are examples of such assets.

Our most famous natural asset is, of course, the Scarborough Bluffs, which are included in our City's Logo. Along the shore of Lake Ontario, we have two beaches (Figure 3) located at Bluffer's Park and at the mouth of the Rouge River. At those beaches, we experience the occasional closure due to high counts of bacteria and other sources of pollution. We have environmental sensitive areas (ESA) and an Environmental Impact Zone (EIZ) along our watercourses. For recreation, we have the Bluffer's Park and the Metropolitan Zoo located in the Rouge River Valley System. (Figure 3)

One of our most sensitive natural and environmental asset is fisheries - which depends on good water quality in our rivers and lakes. The fishery is a natural asset, as it attracts tourism and provides revenue. It is also an environmental asset because a healthy fishery is an indicator of a healthy ecosystem.

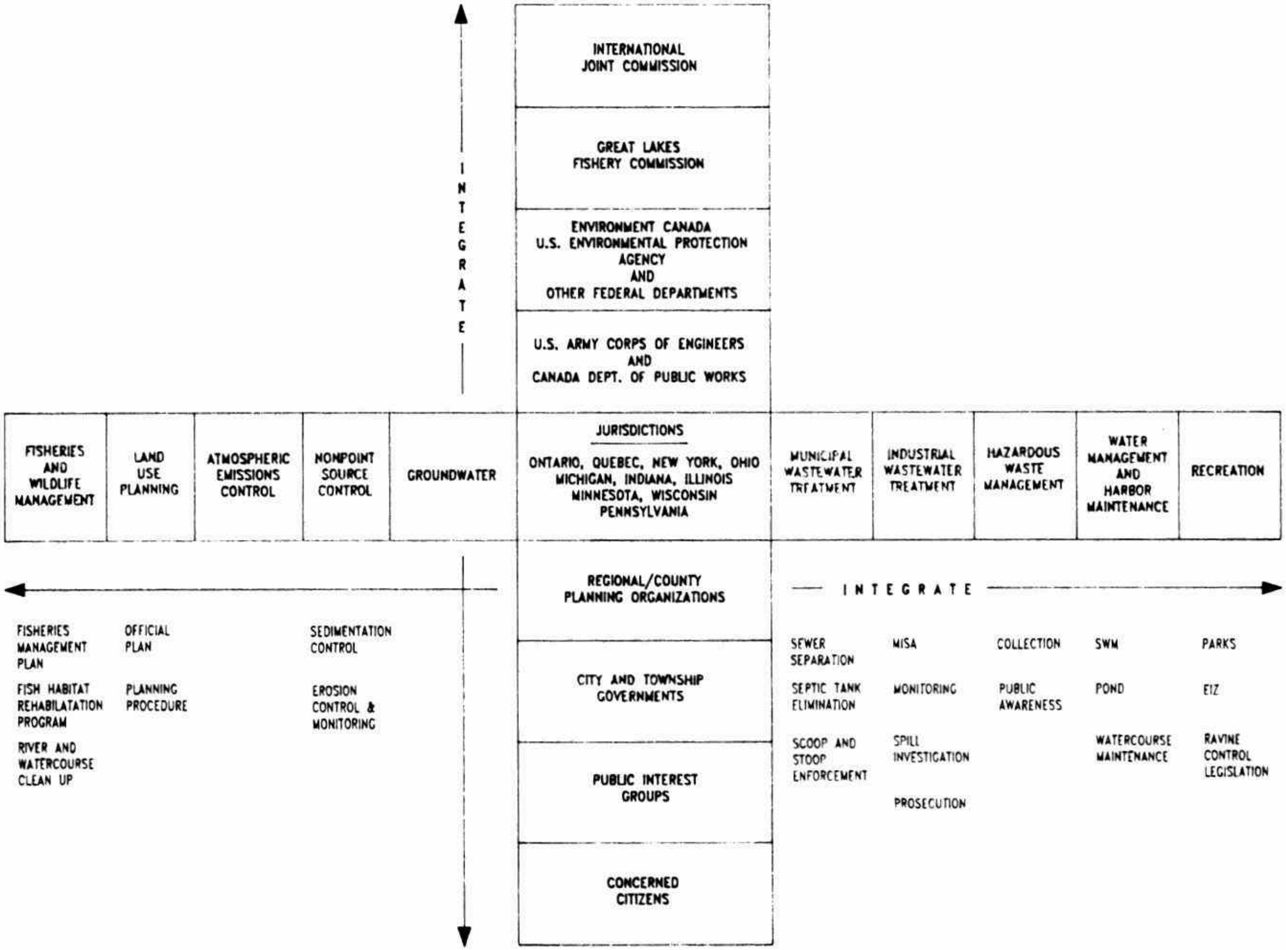

Figure 2: A Two-Dimensional Schematic Diagram Which Depicts the Need to Integrate the Responsibilities of Different Agencies, Oraganization and Programs under the Umbrella of a Remedial Action Plan

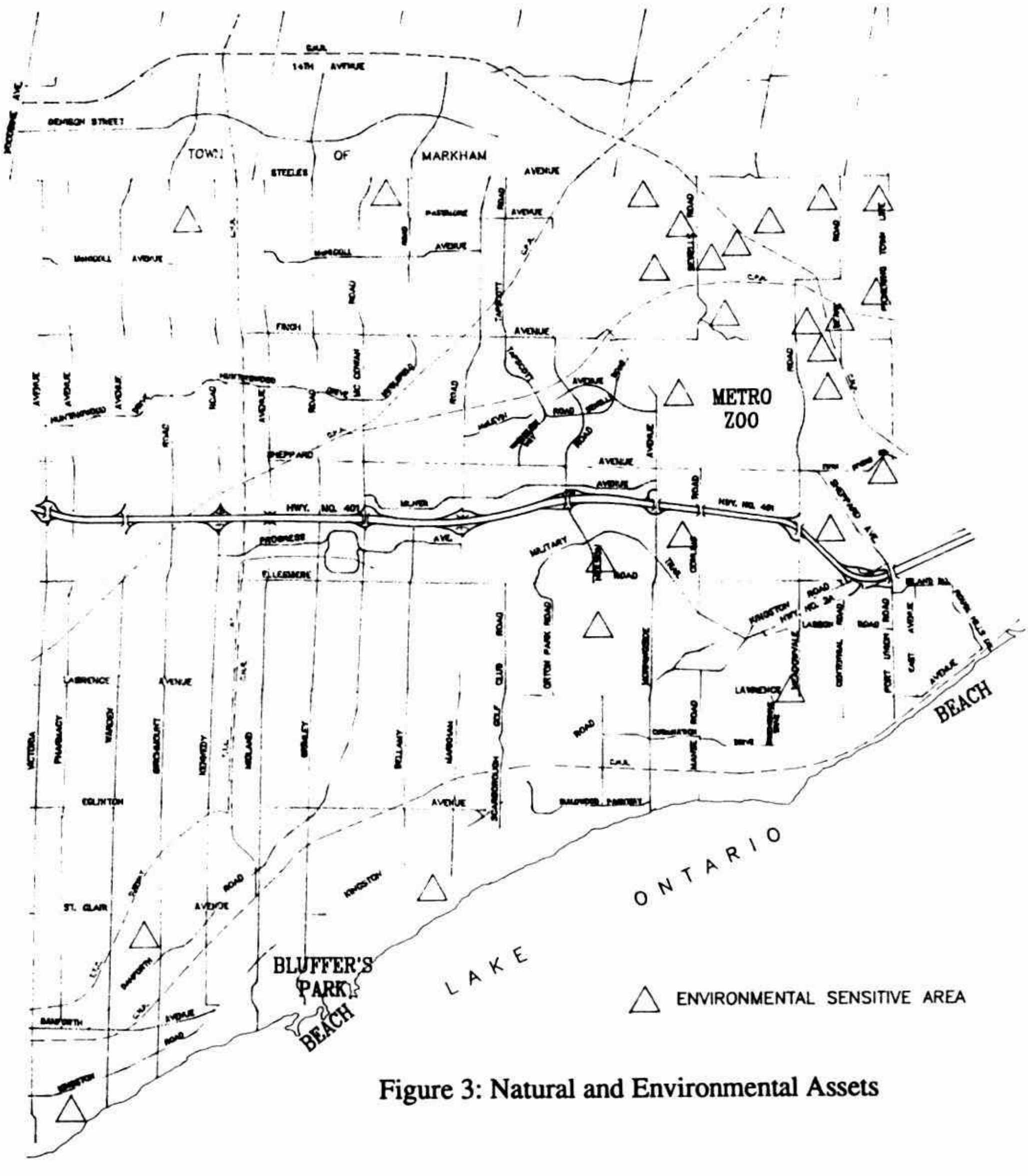

Figure 3: Natural and Environmental Assets

14.4 Sources of Pollution

In Scarborough, sources of water pollution include combined sewer overflows, storm sewer discharges (Figure 4), and water pollution control plant (WPCP) discharges. Combined sewer overflows discharge to Lake Ontario and Massey Creek, a tributary of the Don River. These contribute to the closing of beaches after a rainstorm. The city's sanitary sewage is treated at two WPCPs which discharge to Lake Ontario: the Highland Creek plant which is located in Scarborough and the main plant located in the City of Toronto. There are sanitary trunk sewers which are so surcharged that residents complain of raw sewage flowing down the street!

Other sources of waterborne pollution include old landfill sites, defective septic tanks and spills. In Scarborough we respond, on average, to three to four spills per week, of which 80% are petroleum products. About 95% of spills are five gallons or less. A few spills are quite large, such as: 1000 gallons of double strength chlorine bleach, 500 gallons of leaded gasoline, 200 gallons of children's finger paint, and 30 gallons of styrene.

14.5 Municipal Implementation of Storm Water Quality Controls

Recognizing the value of our natural and environmental assets, the Council of the City of Scarborough adopted three significant recommendations involving storm water quality. It:

a. Requested the Ministry of the Environment to prepare Storm Water Quality Guidelines related to urban runoff.

b. Requested the Metropolitan Toronto and Region Conservation Authority (M.T.R.C.A.) to undertake an Urban Watershed Study, the Rouge River Urban Drainage Study, in 1985.

c. Requested that new subdivisions draining into the Rouge River, consider water quality in order to address the requirement for swimming and fishing in the Rouge River.

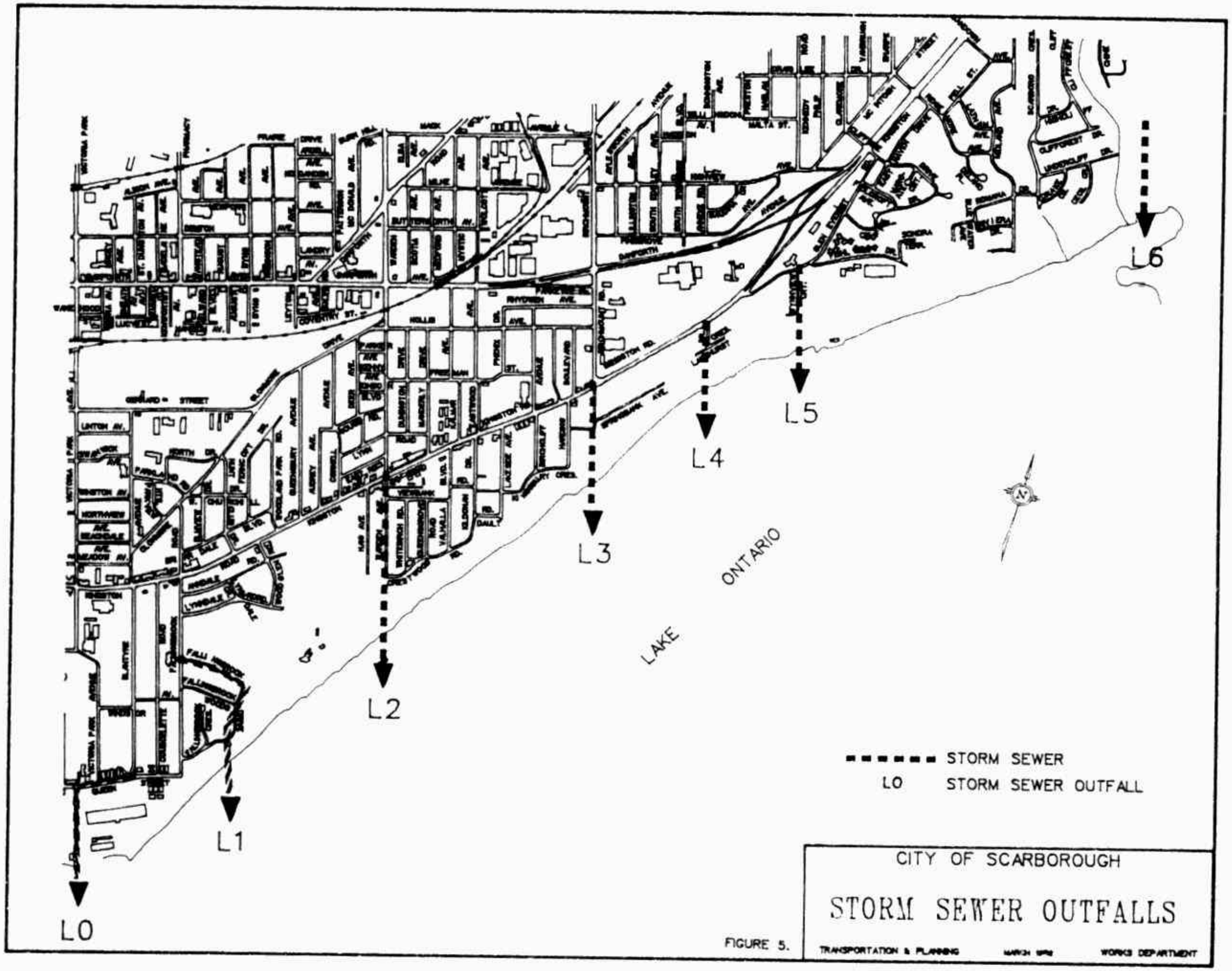

Figure 4: City of Scarborough Storm Sewer Outlets

The Ministries of Environment and Natural Resources have prepared the Interim Storm Water Quality Control Guidelines. The M.T.R.C.A. is in the process of developing an implementation plan for the Management Strategy for the Rouge River Watershed. With these two documents, Scarborough is coming closer to determining how to implement storm water quality controls.

To assist implementation of stormwater quality controls, the following storm water management planning and design procedure for new development is proposed (see Figure 5) to stimulate discussion and comments. [Editors' Note: An updated version of the planning protocol recently developed is given in Chapter 3 of this volume.]

14.5.1 Official Plan

The Official Plan is the first tool municipalities use for controlling development and for establishing the requirements for infrastructure. As one of the first steps toward incorporating storm water quality policies in the Official Plan, we feel that the Ministry of the Environment, and the Ministry of Natural Resources, in conjunction with the Conservation Authority, must establish quality objectives of the receiving watershed.

In its present form, the interim stormwater quality control guidelines (MOE, MNR, 1991; see also Chapter 3 of this volume) define the level of control based on two sensitivities:

Sensitive Area: areas where storm water from new development has potential to impact water bodies with existing/potential cold water fisheries.

Less Sensitive Area: areas where storm water from new development has potential to impact water bodies that support uses of existing/potential warm water fisheries.

It must be recognized that a single water body may have several sections with different levels of controls, as was demonstrated in the Rouge River study (see Figure 6 from M.T.R.C.A., 1989).

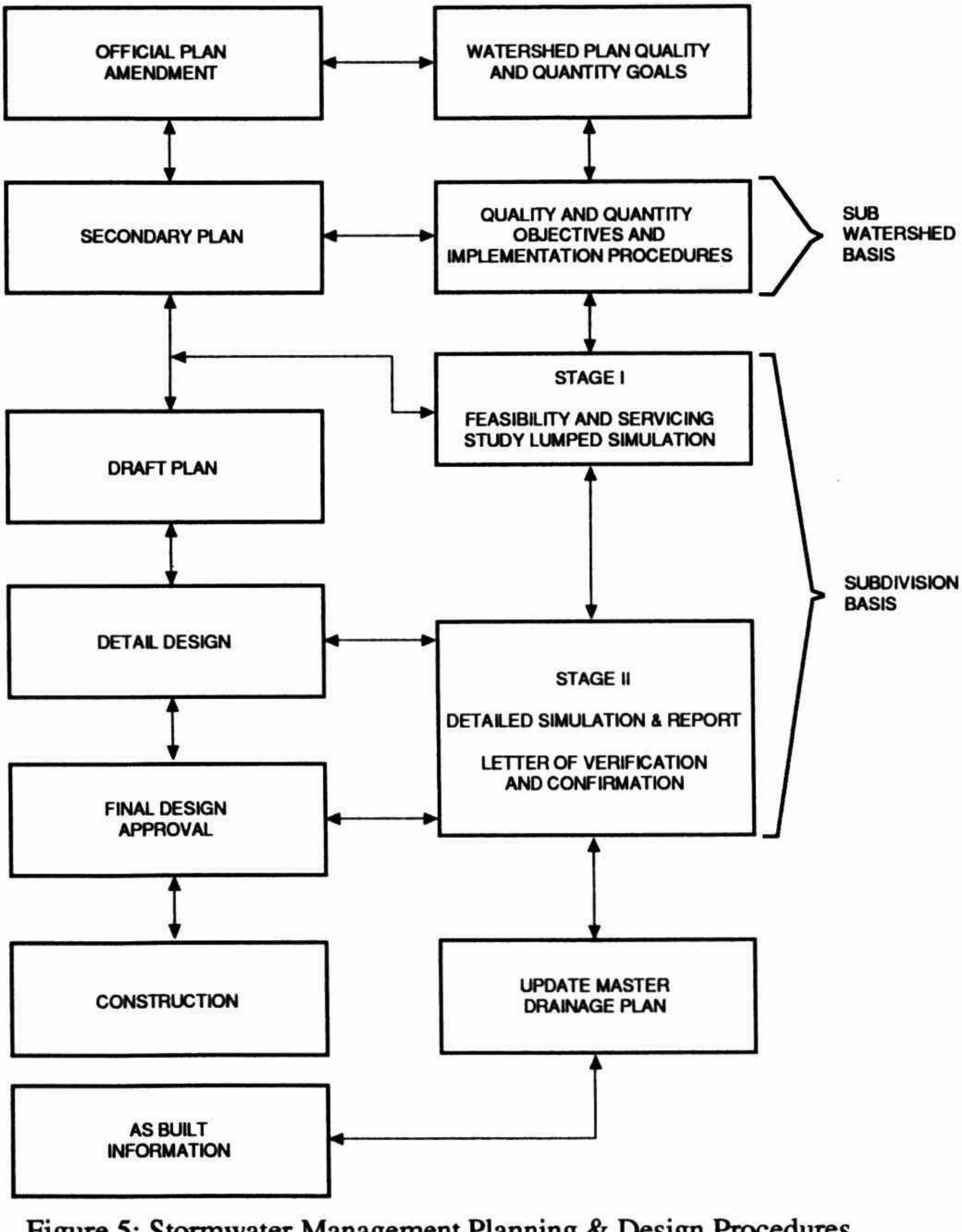

Figure 5: Stormwater Management Planning & Design Procedures

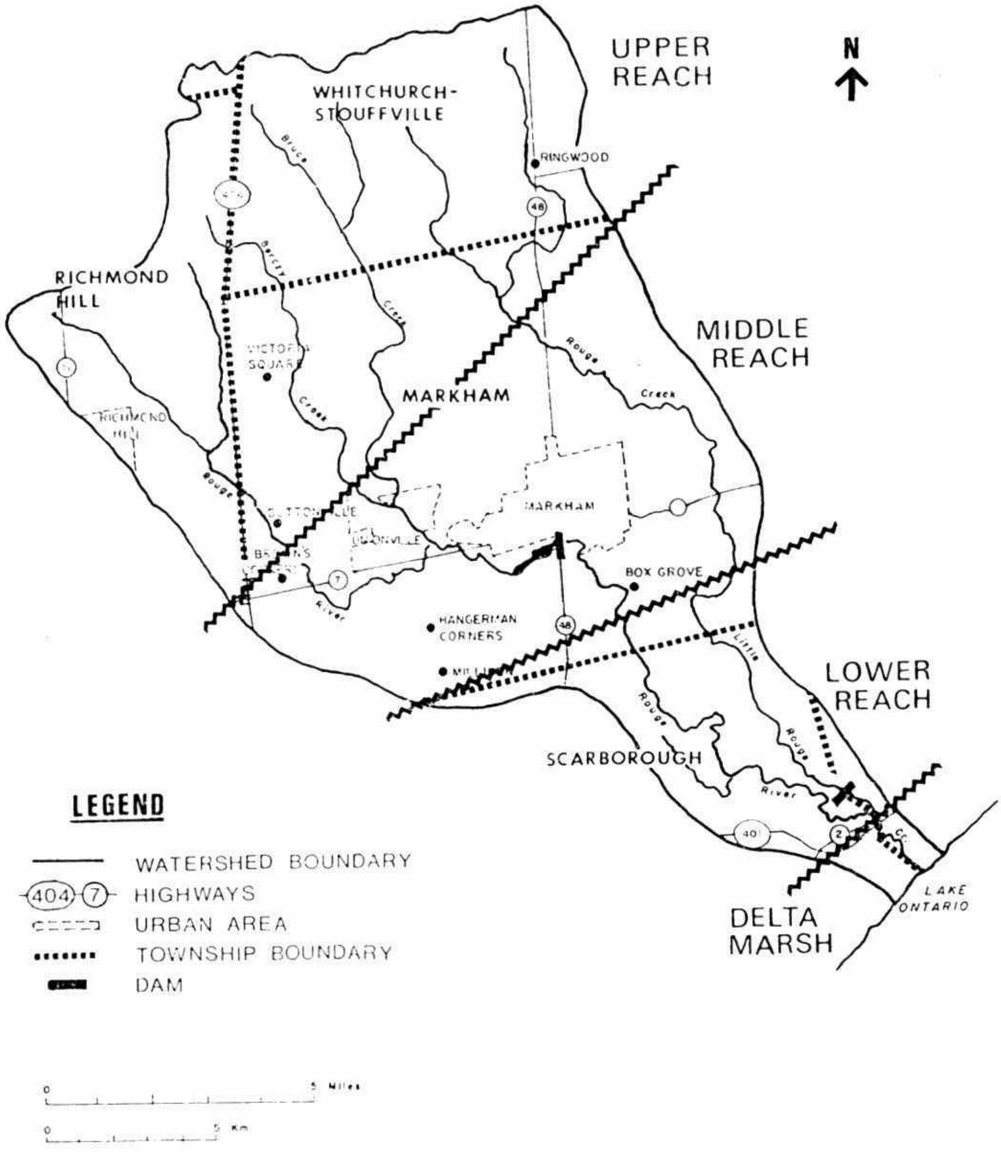

Figure 6: Rouge River Management Zone

The upper reaches of the Rouge River sustain a cold water fishery which would qualify it as a sensitive area. The middle reach does not have the temperature and quality parameters required to sustain a cold water fishery. Therefore the "less-sensitive" category would apply.

In the lower reach, water quality meets requirements which permit a migrating cold water fishery in this section. The sensitive category would apply.

Once these limits have been defined by the ministries, the Official Plan can incorporate policies which contain basic goals and objectives that provide for the protection of and where necessary, the enhancement of water quality and fish habitat. A sample wording of such policies is provided:

> "In consultation and cooperation with the Ministry of the Environment, the Ministry of Natural Resources, and the Metropolitan Toronto and Region Conservation Authority, ensure that there is a storm water management program in place which seeks the maintenance and upgrading of water quality in the receiving water."

14.5.2 Secondary Plan and Draft Plan

At the secondary plan stage, policies of the Official Plan are refined to produce detail requirements. At this time, it is advisable that stormwater quality methods (i.e. whether centralized vs. localized control techniques are chosen for a drainage area) and location of control facilities be identified along with the number and location of outlets to any watercourse, taking into consideration any environmentally sensitive areas. The timing of designing and implementing certain works and submission of report relative to development should be identified. It has been our experience that certain requirements are best met before submission of an application for draft plan approval. These requirements include delineation of the top of bank and development limits, servicing report, SWM Stage I Report, etc. With regard to Stormwater Quality Control, it is also best that the applicant start discussions with the ministries and the municipalities, before a plan is prepared for circulation, regarding methods to be used for quality control.

POLLUTION CONTROL IMPLEMENTATION

By the time a plan is submitted for draft plan approval, any land required for a storm water facility should have been identified, set backs along the watercourse should have been defined, and methods and level of controlling quantity and quality should have been agreed upon. We suggest the following wording for requirement and inclusion in the Secondary Plan.

> "A storm water management plan addressing both quality and quantity mitigation measures shall be submitted for review by the municipality and the Ministries of the Environment and Natural Resources prior to the submission of an application for a draft plan approval. This requirement is applicable for lands designated as sensitive and less-sensitive in Schedule X of the Official Plan."

During our review of implementation procedures, we have come across several problem areas and there is one which we feel should be brought to your attention . One particular problem area is the onerous approval process and conflicting objectives if a retention pond is proposed on-line. M.O.E. has delegated storm sewer review to Metropolitan Toronto under the transfer of approval program: however ponds which are an extension of the sewer works still require review and approval by M.O.E. At the same time, an on-line pond falls under the Lakes and Rivers Improvement Act and requires M.N.R. approval. These ministries review any stormwater management (S.W.M.) reports, as do the Conservation Authority, Metropolitan Toronto and the Municipalities. Hence, we have five different governmental agencies reviewing the same pond and having different requirements.

A review of these different requirements indicates the following:

M.O.E.:	Because of its value as a sedimentation basin, M.O.E. prefers a retention pond with a top withdrawal from the ponded water.
M.N.R.:	Because retention pond heats up during the summer, MNR prefers a pond with a bottom withdrawal detaining at least 125 cu. m/ha from development for 12 hours.

CONSERVATION AUTHORITY:	Requires that the 2 year post development peak flow be reduced to 2 year pre-development peak flow.
METROPOLITAN: TORONTO:	Requirement unknown. They are still not recognizing overland flow on their roads.
SCARBOROUGH:	Requires 5 year post-development peak flow reduced to 5 year pre-development peak flow, with a possible future requirement for trapping spills. Retention ponds are discouraged because of potential liability.

Some of the readers of this book are consultants and we certainly do not envy you in trying to meet all the requirements. Since new guidelines are being introduced, it may be time for the Provincial Government to review its approval process. We endorse the M.N.R., M.O.E. and Conservation Authorities initiative to try "one-stop" shopping for development approvals. [Editors' Note: An example of this initiative is the proposed agreement between the MNR and the Credit Valley Conservation Authority (CVCA).]

Since the MTRCA is also developing an implementation plan for the Rouge River Watershed, some of the goals and objectives will assist in rationalizing these conflicting requirements upon an environmental basis. But, the decision to adopt one agency's criteria over the other may be made on the basis of statutory authority rather than environmental or technical feasibility, a point which is further addressed below.

14.6 Relevant Findings of the Crombie Commission

The Interim Report of the Royal Commission on the Future of the Toronto Waterfront was published in August 1989. A second interim report was published in 1990. The final report was published in May 1992.

With regard to the impact on the watershed, the reports state that the most serious source of contaminants, affecting the quality of Lake Ontario's nearshore water, sediments and biota are from tributary streams, water pollution treatment plants and combined sewer overflows. Stormwater discharges were poorest in the sewers draining predominantly industrial lands. There is a high frequency of observed "spills" which indicates that accidental or illicit dumping of contaminants into the storm sewers is widespread.

The strongest and most frequently voiced concerns to the Royal Commission, are having to wait for the results of another study when plenty of studies have already identified the problems and made appropriate recommendations.

Some key recommendations from the Crombie report include the following statements:

> "The responsible agencies should undertake remedial actions as they are recommended for these watersheds ... "
>
> "Any new development or redevelopment in Toronto area watersheds should be approved only on the basis of the best available technology, economically achievable."
>
> "... priorities in pollution abatement will need to be determined, resource requirements specified, scheduling of remedial actions completed, cost commitments secured, and monitoring and surveillance programs confirmed."

14.7 Implications of Stormwater Quality Controls

The following is a list of issues related to Storm Water Quality and the Environment in general.

1. AWARENESS: As the public is becoming more and more aware of pollution and its effects on our rivers and lakes and sources of drinking water, we, as municipal employees must be prepared to address environmental concerns. In Scarborough, the Works department took the initiative to publish an environmental newsletter to advise staff and the politicians of the department's environment-related activities. For the public, we developed a booklet called "Important Information for Home Owners." in which we explain the functions of storm and sanitary sewers and what is permitted to be discharged into these sewers.

2.	EDUCATION:	Stormwater Quantity Control workshops are abundant, however stormwater quality control workshops are few in number. Stormwater Quality Control education is still at the level of Conference and Seminar such as the one from which this book was derived. Conferences such as "The Engineering Foundation Conferences" (see references for citation) are useful sources of research information. However, design standards are yet to be established.
3.	DRY VERSUS WET POND:	The M.O.E. and M.N.R. recommend a retention rather than a detention pond. The position adopted by Scarborough's Legal Department in consultation with our Risk and Insurance Manager is that the liability of retention outweighs the benefit to the environment. A compromise was reached with the proposal for a combination of skimmer/ sedimentation (wet) pond (a small pond to remove large suspended solids) followed by dry quantity pond.
4.	MUNICIPAL PARTICIPATION IN STUDIES ETC.:	Municipal involvement in multi-agencies committees such as the RAP (the Metropolitan Toronto Remedial Action Plan), TAWMS (the Toronto Area Watershed Management Strategy), and the Rouge River Study has skyrocketed. Numerous studies have been and are being undertaken.
5.	ENVIRONMENTAL ADVISORY COMMITTEE:	This committee, made up of politicians, staff and the public, advises Scarborough Council on matters related to the Environment. We also have a Waterfront Committee which deals with the Lake Waterfront.
6.	TOP OF BANK COMMITTEE:	This committee is comprised of staff from the M.T.R.C.A., and from Scarborough's Works, Planning and Recreation & Parks Departments. They go into the field to establish top of bank, to delineate the limit of development as well

as to define where the Scarborough Ravine Control By-law applies. This bylaw is used to identify headwaters where M.T.R.C.A. jurisdiction ends. The Ravine Control By-law benefits water quality by controlling the cutting and removal of trees and vegetation needed to protect the temperature in streams. The Conservation Authority will use its legislation to encompass the area that this committee maps to extend their Fill Regulations.

7. COMPLETION OF FLOOD MAPPING: It is necessary to determine limits of development in areas not mapped by M.T.R.C.A.

8. FISHERIES: A healthy fishery is a good indicator of successful pollution control, as well as being a tourist attraction and a source of revenue for the municipality. In 1985, Scarborough published a report "Biological Fishery" which indicated a potential revenue of $15.5 million if residents fish within Scarborough. Research by the Toronto Star determined that $10.7 million was spent in Port Credit during the 1979 Salmon Hunt. In 1987, Council assigned the mandate for dealing with matters related to fisheries to the Works Department.

9. STAFFING: In order to handle water quality control, we found that an environmentalist, a biologist and an hydrologist must be on staff. The Works Department is fortunate to have these three positions and the appropriate professionals in them.

10. MULTI DEPARTMENT EFFORT: One municipal department cannot carry all the effort required for successful stormwater quality management. The participation of the Planning, Parks and Building and Works Departments is a must.

11.	PUBLIC INTEREST GROUPS PARTICIPATION:	Municipalities must be prepared to include participation of non-government organizations (NGO) and citizen groups in stormwater quality management. We witnessed such participation when over 1500 residents attended the debate on the Scarborough North East Land Use Study. Two Planning Committee meetings (12 hours total) and two Council meetings (12 hours total) were allocated to hear debates and deputation.
12.	POLITICAL SUPPORT:	In Scarborough, we consider ourselves lucky to have strong political support for our environmental initiatives.
13.	RESEARCH:	This is one field in which we feel that municipalities should not be involved. However, we find that we are getting more and more involved. Research can take two forms: assessment of facilities at other locations and development of research efforts within a municipality such as Scarborough. Research into facilities at other locations may become an essential part of municipal endeavours.

14.8 Liability

What is the municipality's liability if it decides to include stormwater quality as part of its storm water management program. The City of Scarborough has recently gone through an experience which has changed its attitudes. The experience revolves around a court suit brought by the Scarborough Golf and Country Club. The issues brought up at the trial and their legal basis, the decision in the judgement, and the decision from the appeal are now used to define the liability issues that we see to be important in stormwater quality management.

1. <u>Description of Court Proceedings</u>

In 1980 the Scarborough Golf and Country Club brought an action against the City of Scarborough and other agencies for:

a) Interference with the Plaintiff's riparian rights,

b) Nuisance, and

c) Negligence.

In 1986, a year after a lengthy trial, Mr. Justice Cromarty found the City liable on all three bases. While the decisions largely revolved around quantity and erosion issues, it has potentially far-reaching implications for stormwater quality control. The principal basis for his findings, in our view, were his interpretation of: (i) riparian rights concepts as developed by case law; and (ii) the applicable provisions of the Ontario Municipal Act. In 1988, the City's appeal to the Court of Appeal was heard and a judgement rendered in the same year. During the appeal, the applicable sections from the Ontario Water Resources Act were first argued.

2. <u>Definition of Key Terms</u>

Before considering the implications of the court case for stormwater quality control, three legal definitions need to be addressed. The definitions are: (i) whether water quality is, or is not, a part of the riparian code; (ii) the nature of interference; and (iii) the use of the water.

First of all, **is water quality part of the Riparian Code**?

Mr. J. D. Cameron, LL.B., gave an appropriate answer to this question in his presentation to the 6th Annual M.E.A. Workshop.

"Generally speaking, a riparian owner has the proprietary right to have the water in the natural watercourse flow to him in its natural state, neither increased nor diminished in quantity or quality. He is also entitled to use it for domestic and natural purposes".

On **the nature of** interference, he said "There are many types of work that have been held to constitute interference with the natural channel of a stream, such as deepening the channel, removing silt or gravel, straightening the course of a stream, etc."

On the **use of water**,we offer our own comments. It is clear that the quality of the water, by definition, must be whatever it was in its natural state, under the riparian law. Further it should be of such quality to permit domestic or natural uses.

What is the definition of domestic purposes? We do not have an explicit definition. Rather we leave this question to each individual to ponder and take the appropriate course of action.

3. Liability Issues

From the Scarborough Golf and Country Club versus the City of Scarborough litigation, there are several aspects of the logic underlying the judgments which will affect how we approach storm water quality control.

i) On Sediment

One witness for the plaintiff gave his opinion that there was more erosion in the creek through the Golf Club lands than elsewhere because there was a smaller amount of bank protection and there was no supply of sediment coming down from upstream for natural self repair.

ii) On Pollution as a Nuisance

(a) Common Law

At common law, nuisance consists of "the unreasonable interference with another's use or enjoyment of his land. In other words, a nuisance can consist of material injury to property or the creation of a sensible discomfort to the property owners."

In the case of Groat v. City of Edmonton (1928), quoted with approval by Mr. Justice Cromarty, Rinfret J. said:

> "The right of a riparian proprietor to drain his land into a natural stream is an undoubted common law right, but it may not be exercised to the injury and damage of the riparian proprietor below and it can afford no

> defense to action for polluting the water in the stream. Pollution is always unlawful and, in itself, constitutes a nuisance."

Author's comment: We note that in 1928, pollution was already a concern.

(b) The Defence of Statutory Authority Under the Municipal Act

In respect of the allegations of nuisance, the City had argued that the Municipal Act authorized construction of the drainage system which resulted in the nuisance to the Golf Club. The City argued that this gave them a defence of statutory authority.

However, Mr. Justice Cromarty pointed out that for such a defence to succeed a defendant must prove that the nuisance it created was the "inevitable result" of doing something which has been authorized by statute. He also accepted the statement of Viscount Dunedin in the case of Manchester Corporation v. Farnsworth:

> "The onus of proving that the result is inevitable is on those who wish to escape liability for nuisance, but the criterion of inevitability is not what is theoretically possible but what is possible according to the state of scientific knowledge at the time, having also in view certain common sense appreciation which cannot be rigidly defined of practical feasibility in view of situation and expense."

Mr. J. Cromarty added that this principle has been accepted in Canada.

Author's comment: It is the assertion of the authors that with the publication of guidelines and design procedures, reduction of pollution is no longer a theoretical possibility but a practical feasibility.

In concluding that there was nothing inevitable about the nuisance, Mr. Justice Cromarty states:

> "Certainly there was no evidence nor was there argument made that the particular drainage system employed was the only or the best system that could be devised under the circumstances or that a system could not be devised that avoided causing material injury to the plaintiff."

This is with reference to sewers installed in the pre-storm water management era.

Thus in summary concerning Statutory Authority given by the Ontario Municipal Act, his Honour found that although the Municipal Act gave the City the "power to build and maintain" a stormwater drainage system, it did not contain a "direction to adopt [the] particular method" of drainage which resulted in the nuisance,using the following language:

> "These comments apply with equal force to the paragraphs of the Ontario Municipal Act relied upon by the City. Thus I reject the defense of Statutory Authority in the present case and confirm that the City cannot avoid liability for the nuisance it has created."

Therefore, his Honour rejects the defence of statutory authority in this case.

Author's comment: In our review of the trial judgement, it is not clear whether a municipality should adopt a Storm Water Quality Policy as no protection is provided for the design, construction, maintenance of the drainage system.

(c) Appeal - The Defence of Statutory Authority Under the OWR Act

In 1988, the City's appeal to the Court of Appeal was heard and judgment rendered in the same year. During the appeal, the plaintiff tried to expand its defence of statutory authority to rely upon section 30 of the *Ontario Water Resources Act.* Section 30 states:

> "30. Sewage works that are being or have been constructed, maintained or operated with the approval of the former Department of Health, Commission, the executive director, etc. so long as the sewage work are being so constructed or are so constructed, maintained or operated, shall be deemed to be under construction, constructed, maintained or operated by Statutory Authority."

In his reasons for judgement, Mr. Justice Carthy adopted the same law applied by the trial judge, namely, that damage must be inevitable before the defence of statutory authority

is granted. However, he refused to rule on the OWRA's application to the facts of this case since the Act was not pleaded at the trial level, and the evidence at trial did not directly address it.

In his comments, Mr. Justice Carthy leaves open the possibility of a defence of statutory authority based on s.30 of the OWRA. He noted that this section "does not bar a common law action but the Authorities referred to above establish that specific statutory authority, such as here provided to these sewage schemes, does protect the City absent negligence in implementation of the approved scheme and if the resulting damage is inevitable ...".

However, he makes it clear that the evidence will have to go beyond the simple question of whether or not approvals have been issued under the OWRA to include a detailed analysis of each of the successive approvals, discretion available, and the resultant inevitability of the damage. Other causes of the damage not protected by s.30 of the OWRA, such as increases in run-off volume due to increased pavements and buildings will have to be considered as well.

4. Summary

Provided a municipality is not negligent in the design of its stormwater management systems and damage to downstream users is unavoidable regardless of the design or approach adopted by a municipality, the municipality desires to have a defence of statutory authority under section 30 of the *Ontario Water Resources Act* for any damage so caused. As a result of the Scarborough Golf and Country Club case, this defence was not tested in the court case.

It is our interpretation of the Trial and Appeal judgements that, as long as stormwater quality works have been designed in a non-negligent fashion pursuant to a statutory authority, and the downstream nuisance is an inevitable result of the proper exercise of that authority, municipalities may have a defense of "statutory authority". We suggest that necessary technical criteria include that the quality control works have been designed using the latest scientific knowledge, and construction maintenance and operation have been approved under the Ontario Water Resources Act. We do suggest that municipalities consult their Legal Department for an opinion and interpretation of these judgements and law, before using it as a formal basis for developing stormwater quality policies.

14.9 Scarborough Initiatives

Scarborough has built numerous storm water management facilities. The majority are detention ponds, i.e., dry ponds which detain stormwater and then let it all discharge. However, there are three retention ponds.

With the development of stormwater quality guidelines by the Province of Ontario, we believe that the public opinion will turn towards demands for implementation and, "show us how".

Accordingly, Scarborough initiated in 1990, necessary technical studies to facilitate the design and construction of storm water management facilities that address the requirements in the water quality guidelines. One of the key aspects of trying new techniques is to monitor before and after implementation of proposed stormwater quality facilities, the effectiveness of the facility, and hence future modifications.

Similarly a study was initiated in 1989 and completed in 1991 to evaluate the feasibility of installing a water quality facility at one of our storm sewer outlets into Lake Ontario. The proposed outlets drain mainly separated storm sewer systems (Figure 4) but also contain sanitary sewage from combined sewer overflows.

In 1990, the Scarborough Planning Department undertook an Official Plan review which is incorporating many new environmental policies that pertain to water quality, river ecosystems, and tree preservation.

In keeping with our mandate for the protection of our "liquid" assets, the City of Scarborough recommended that the M.N.R. fund a study on the Rouge River to address the fisheries and the need for improved habitat.

14.10 Summary and Future Directions

The City of Scarborough endorses the interim stormwater quality control guidelines. Scarborough Council was one of the first public bodies that requested that they be prepared, so that its technical staff could implement appropriate controls in new development.

But the control of new development is insufficient to only hold the status quo of natural waterways from both a protection point-of-view and from a philosophical point-of-view. It is necessary that plans and works commence on retrofitting quality controls in existing urbanized areas where separate storm sewers have been constructed. The clean up of combined sewer problems are well in hand but the City is targeting the spending of $2 million a year for the next eight to ten years to continue to address this issue.

Rehabilitating streams, rivers and lakes to meet the requirements of a healthy ecosystem including a quality fishery and of public health need new programs and new funding. The City of Scarborough is considering the role that new urban development has for funding the upgrading by contributing through lot levies or Section 36 of the Planning Act. Because Scarborough has a small amount of land left for the development of subdivisions, it is likely that the City will need to turn to existing developments and the municipal tax base.

The local municipality is not in the business of research and, therefore must look to the province to help us monitor, build prototypes, monitor, modify and then monitor again. Whether one is rehabilitating a stream, carrying out erosion control or building quality control ponds, the expertise of consultants, the senior levels of government and academia is needed to provide much of the knowledge base and the tools.

There is no question, that with the introduction of MISA, the Spills Bill, the new Sewer Use By-law, the new Metro Combined Sewer Separation Policy, and the interim stormwater quality control guidelines, the municipalities are faced with increasing their staff, increasing their knowledge and increasing their budgets. Despite what many people believe, it is the municipal engineer who has the bottom line responsibility for cleaning up the environment.

The provincial government has determined that the public wants action regarding the environment and they are giving the municipality the tools, but little funding, to do the job for them. Presuming that Municipal Councils are prepared to bite the bullet (after much grumbling) and we know that Scarborough is, then public works and other municipal staff must press onwards and make use of the new technology.

Using the comments on liability, one can conclude that you are damned if you do and damned if you don't get moving with the new tools. So plan wisely, heed the legal advice and tread lightly BUT KEEP MOVING FORWARDS!

14.11 Acknowledgements

The comments of Jack Coop, Counsel, Ministry of the Environment, on the legal aspects of the Scarborough Golf and Country Club case are gratefully acknowledged.

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CHAPTER 15

Urban Stormwater Management Experience of Governmental Agencies in Ontario

Jonathan C. P'ng

ABSTRACT

The goals of urban stormwater management include preserving and improving stream water quality for present and future uses, protecting life and property from damages, conserving natural resources as well as supporting orderly development. This paper traces a number of inter-agency initiatives in urban stormwater management carried out during the past two decades in Ontario and presents their current status. It examines some of the on-going implementation problems and institutional solutions. Inter-agency co-operation is one of the key components in resolving a number of these problems. The paper briefly reviews the integration of urban stormwater management with the land use planning process.

15.1 Background

In the mid 1970's, a significant amount of research on pollution from urban drainage sources was conducted through the Canada-Ontario Agreement on Great Lakes Water Quality (COA) established in 1971 and the Canada-United States Agreement on Water Quality in 1972. In 1977, the Urban Drainage Policy Committee was formed under the auspices of the COA to consolidate all the research and development findings and propose comprehensive model policies for urban stormwater management that would lead to the alleviation of pollution as well as the resolution of flooding problems in urban areas. The Policy Committee's recommended management approach was described in five policy proposals (COA, 1980):

CHAPTER 15

1) Municipalities, in coordination with the Conservation Authorities, should develop master drainage plans for all watersheds within their boundaries. The purpose of this policy is to foster master drainage planning in rapidly developing municipalities so that storm water drainage systems can be developed in a manner compatible with watershed needs, to identify existing water quality and flooding problems, and to avoid future problems.

2) Municipalities with sewage collection and treatment systems should formulate and implement a comprehensive pollution control strategy that considers both wet and dry weather pollution sources. In the initial stage of the formulation, an in-system review of previously unidentified wet weather sources, volumes and magnitudes of pollution should be carried out. Consideration of receiving water objectives, and the cost and effectiveness of wet weather versus dry weather controls would lead to a final comprehensive strategy. The end result would be more cost-effective investment in municipal pollution control.

3) Drainage systems for all new development should be designed using the major-minor concept, which recognizes the drainage system's dual role of providing conveyance during minor (high frequency) runoff events and minimizing property damage and protecting life during major (rare) runoff events. Expenditures for sewer construction are expected to be reduced since the minor system would be designed to avoid excessive costs incurred by the use of overly conservative design techniques or excessively rare design runoff events, while the major system would be designed to provide protection against damage from runoff events that exceed the capacity of the minor system.

4) Proponents of new urban developments should indicate the effects of the development on the watershed and carry out mitigative measures as required. Hydrologic changes and pollutional effects on the receiving watercourse are considered to be the important effects in this case.

5) Proponents of new urban developments should plan for and carry out an erosion and sediment control program in the planning and construction stages of development, and follow this with an adequate maintenance program. Construction-generated sediment pollution is considered a severe enough problem to justify controls on an across-the-board basis.

In 1980, the Province established the Urban Drainage Policy Implementation Committee (UDPIC) with representatives from the Ministries of Natural Resources (MNR), Environment (MOE), Municipal Affairs (MMA), the Municipal Engineers Association (MEA) and the Association of Conservation Authorities of Ontario (ACAO). The Committee's mandate was to examine the COA model drainage policies and provide recommendations on their use in Ontario. The committee concluded that the drainage objectives and model policies in the COA report were appropriate for Ontario. It determined that adequate legislation existed to support these policies and administrative procedures were available to adopt and implement them. The implementation committee initiated the Urban Drainage Management Program (UDMP) for new developments and prepared two supporting technical guidelines.

- Urban Drainage Design Guidelines (UDPIC, 1987)
- Guidelines on Erosion and Sediment Control for Urban Construction Sites (UDPIC, 1987).

A key component of the UDMP was that Master drainage plans and stormwater management plans were considered the most appropriate means for incorporating watershed constraints and implementing drainage control requirements in newly developing areas. These urban drainage plans were to be integrated with the normal land development process.

15.2 Urban Drainage Management Program (UDMP)

The Urban Drainage Management Program advocated a more pro-active planning approach for stormwater management. This approach was described in the urban drainage design guidelines. The first level of planning is encompassed in a Watershed Plan that define water targets for various areas of the watershed. Within these areas targets are established primarily for water quantity and in some cases for water quality point sources discharges. Where appropriate these targets would be addressed in a municipality's Official Plan.

The second level of planning is the preparation of a Master Drainage Plan (MDP) for subwatersheds of the larger plan. At this level, the municipality determines the SWM measures such as approximate sizes and location of channels, quantity and quality ponds

and other measures. The Secondary Plan should be prepared together with the Master Drainage Plan.

The third level of planning is the draft plan of subdivision where the preliminary Stormwater Management (SWM) Plan should be prepared. Based on the street and lot layouts, the major and minor systems and how the facilities will meet the constraints and requirements of the MDP will be defined. The Final SWM Plan will include the detailed design drawings documenting how the SWM measures meet the targets of the MDP and the Watershed Plan. Through this planning process the chicken-pox approach where on-site detention is built for every individual development will hopefully be avoided.

Some of the key features of the program (UDPIC, 1985) are:

- it is not a policy statement under Section 3 of the Planning Act, 1983;
- it forms an integral component of watershed management and flood plain management;
- it is intended for new development; and
- it is to be implemented with the two technical guidelines above.

Conservation authorities and municipalities have been identified as the key to Program implementation.

15.3 SWM Implementation Experience in Ontari

The UDMP with the two technical guidelines addressed four of the five policy proposals, related to new development. But since the UDMP was not included in a policy statement under the Planning Act, it was essentially a voluntary program with implementation left up to the local municipalities. A survey of municipalities (MOE, 1985) with a population of 10,000 and greater was carried out to determine the level of stormwater management practices in Ontario. Forty-four municipalities (62% of respondents, 71 out of 110 municipalities responded) were employing SWM practices to varying degrees. A majority of rapidly growing municipalities adopted official SWM policies. Thirty municipalities had undertaken Master Drainage Planning and 17 municipalities had an official policy requiring MDPs. Although there are more municipalities which have undertaken master drainage planning since the survey, Master Drainage Planning has not been carried out

widely or in a consistent manner. There were not many completed watershed plans that had identified urban drainage targets. Watershed Plans that were carried out in the 70's and early 80's such as the Thames River Basin (1975) the Grand River Basin Water Management Studies (1982), and the Stratford-Avon River Environmental Management Project (1984) were focused on solving flooding and point source pollution problems. This showed that the voluntary program had not resulted in consistent application of SWM.

Stormwater management was carried out mostly on a subdivision basis and not based on a watershed or subwatershed plan. Development pressures in the 1980's aggravated the situation. Many SWM plans were done using the criteria of reducing the post-development peak flows to pre-development peak flows. However, the Rouge River study (MTRCA, 1989) concluded that a "blanket" policy of runoff control for flood control purposes was effective locally but was not effective on a watershed basis. A blanket policy was not effective for erosion control because erosion was a complex site-specific phenomenon. This demonstrated that the typical approach to SWM in the 1970's and 80's which did not follow watershed planning was not effective.

Previously very few municipalities had adopted SWM practices related to quality control because the main emphasis of the UDMP was on quantity control. This was reflected in the urban drainage design guidelines which only made brief references to stormwater quality management. Urban stormwater runoff has been identified as a major contributor to the water quality problems of many rivers with urbanized watersheds, e.g., the Don River (MOE, 1989). If stormwater quality controls are not implemented, rivers like the Rouge River and Credit River subject to urbanization pressures may become as degraded as the Don River in 30 - 50 years time. Clean-up costs after the fact would be astronomical, e.g. Don River clean-up is estimated at 1 billion dollars.

More recent watershed plans have addressed the problems and solutions of urban stormwater quality. These plans include the Strategy for Improvement of Don River Water Quality (P. Theil, 1989) and the Basin Management Strategy for the Rouge River Watershed (MTRCA, 1989). The Rouge study recommended the development of watershed-based policies for urban stormwater management to improve stormwater quality. It also recommended that master drainage plans include multiple objectives such as flood and erosion control, fisheries, water quality, and terrestrial and riparian habitat. SWM practices which have not been widely adopted should be considered, e.g., infiltration practices. Where feasible, these control structures would improve stormwater

quality discharged to the receiving waters and increase baseflow to the streams. It was recognized that the traditional approach to SWM was too narrowly focused and needed to be expanded to include other watershed objectives.

Although the guidelines for erosion and sediment control were available for a number of years, there was little implementation. Land may be stripped bare of vegetation for months before any construction begins. Erosion and sediment controls were not enforced at most construction sites. This was due to a severe shortage of inspectors who could enforce them.

15.3.1 Mandates of Different Government Agencies

Urban stormwater management involves different provincial and municipal agencies with different mandates. MOE, through the Ontario Water Resources Act (OWRA), issues approvals for sewage works which include all storm sewers and stormwater management ponds. MOE also administers the Environmental Assessment Act which applies to municipal projects.

The Ministry of Municipal Affairs administers the Planning Act which establishes the legislative framework for municipal official plans. These plans set out general policies for development and redevelopment in a municipality. The ministry reviews subdivision applications and co-ordinates the implementation of provincial concerns through the approval of these plans.

The Ministry of Natural Resources (MNR) through the provisions of the Lakes and Rivers Improvement Act and the Federal Fisheries Act, address sedimentation and the deleterious effects to fish habitat. Through the Lakes and Rivers Improvement Act, MNR issues approval of works (alterations and diversions) in lakes and watercourses.

MNR, together with the Conservation Authorities, administer the Conservation Authorities Act. MNR will provide technical and financial assistance to Conservation Authorities in the development of Watershed Plans that identify urban drainage targets. Conservation Authorities are defined on a watershed boundary basis. They are responsible to plan, develop and operate flood control, resource management, water conservation and recreation programs. They develop watershed plans to provide a comprehensive basis to

implement these programs. Through the Conservation Authorities Act they issue approval of activities related to water quantity.

The Municipal Act/Regional Act provide municipalities with legislative authority for involvement in construction and operation of drainage and storm water works. The municipalities are also responsible for drainage bylaws, codes, criteria and subdivision agreements with developers.

Due to the number of agencies involved in the approval process, each with their own mandate, delays, duplication and conflicting requirements have occurred. To avoid problems, each agency would need co-ordination with the other agencies to outline their requirements early in the planning process. Drainage and environmental planning should be integrated together with land use planning. Agency requirements should be made known at the watershed and subwatershed planning levels through agency representation at the steering committees.

Under the existing circumstances, the conservation authorities and the municipalities are the most well-placed agencies to implement stormwater quality management. Conservation authorities and municipalities lack resources in certain areas such as research and technology development. Provincial ministries can play a strong role in these areas by sponsoring training and education programs and providing technical expertise. Conservation authorities understand their watershed and would be well-placed to co-ordinate the different municipalities in the watershed.

15.3.2 Upstream and Downstream Municipalities

In many watersheds municipalities have developed near the major watercourses generally in an upstream pattern. In these watersheds there may be a number of municipalities which are almost fully developed. In many cases, new development is still occurring in the upstream areas. Some upstream municipalities may question why they have to put in stormwater quality controls when downstream municipalities have none. A watershed plan can be used to justify where controls should be implemented to be most effective.

The implementation of quality controls in all new developments would mitigate further degradation occurring in the watershed. This is the intent of the Interim Stormwater

Quality Control Guidelines for New Development (MOE/MNR, 1991) described in chapter 3. The guidelines were intended to provide direction to development proponents in the preparation of stormwater management plans for water quality control in areas where watershed or subwatershed plans have not been done. They have been adopted by a number of MOE and MNR Regional and District offices and some municipalities.

15.3.3 Public Attention

The environment is an important public issue and much media attention has focused on it. Our daily newspapers and radio and television newscasts are filled with reports on the environment. This has resulted in heightening public awareness on environmental issues. However, inaccurate reporting has also generated a lot of misconceptions about the environment. For example, a television report stated that if you just dip your hand in the water of the Don River in Metro Toronto, your skin will literally peel off.

Public expectations are high. A newspaper article reported that a City of Toronto committee had recommended the initiation of a clean-up program of the Don River with an estimated price tag of $100 million. A city councillor was quoted as saying that he wanted kids to be able to swim in it by the year 2000. When a study report was released the following week which estimated the Don River clean-up costs at $1 billion, the same city councillor was then quoted as saying "We have no choice but to clean up, if not for us then for the sake of our children". The one-order magnitude jump in costs did not change his position.

Public comments received during public participation forums have indicated that the public is tired of more and more studies. They want action. They want pollution control to be implemented at best available technology. The public is not willing just to sit back and wait. Concerned citizens have joined environmental interest groups like the "Save the Rouge Valley System" in Scarborough. These groups are well-organized, active and are putting pressure on politicians to respond. And some politicians are responding. Politicians in recent municipal elections have been elected because of their environmental stand.

A city engineer remarked at this seminar that if the public perceives a problem, then it is a problem (to the city councillors). There will be increasing public pressure for

environmental controls. It is better to take a more pro-active approach and plan ahead instead of resorting to the piece-meal approach in response to public pressure.

15.4 Recent SWM Implementation Experience

There have been significant changes in the past few years in stormwater quality management. This has been helped by the release of reports by the Royal Commission on the Future of the Toronto Waterfront and the Greater Toronto Greenlands Strategy. There is greater public awareness that urbanization can have adverse impacts on streams and other receiving water bodies. In addition to flooding and erosion, there are problems such as increased pollutant loadings, temperature effects, baseflow reduction, habitat changes and groundwater impacts. Degraded watercourses in urban areas are very difficult and costly to restore. Therefore the mitigation of stormwater impacts of stormwater impacts must be addressed during the planning, design and construction stages of urban development. There is a need for a new and broader approach to stormwater management that would be based on all water and resource management concerns. This involves the integration of comprehensive resource management planning on a watershed basis with municipal land use planning and the use of Best Management Practices (BMPs) such as conservation practices, source control, site planning techniques, vegetative practices and structural measures e.g. extended detention ponds, wet ponds, infiltration practices, constructed wetlands.

There has also been changes in the enforcement of regulations. The Federal Fisheries Act is a very powerful piece of legislation that provides for the conservation and protection of fish and fish habitat. It prohibits the destruction of fish habitat and the deposit of deleterious substances in water frequented by fish. MNR has been active in enforcing the Fisheries Act. Since stormwater contains deleterious substances, stormwater quality controls are being required.

15.4.1 Watershed Planning and Land Use Planning

The Commission on Planning and Development Reform in Ontario headed by John Sewell is conducting public forums on all aspects of the land use planning system. The Commission will be making recommendations on changes to the Planning Act. One of the

draft goals of the Commission is to protect, sustain and enhance the integrity of the natural environment and ecosystems. The integration of watershed planning and land use planning will be definitely affected by the outcome of the Commission's recommendations.

In the interim provincial ministries and other agencies are jointly developing three guidance documents on watershed planning, subwatershed planning and the integration of provincial water resource management objectives into municipal planning documents. The aim is to integrate watershed planning with land use planning. These guidance documents are expected to be released in 1992.

15.4.2 Best Management Practices (BMPs)

In order to provide guidance for implementing BMPs, MOE initiated a two-phase project to develop a stormwater quality BMP planning and design manual. Although other North American jurisdictions have produced BMP design manuals, their use in Ontario may not always be suitable because of climatic, topographical, political and other differences. The Phase 1 report was completed in 1991 (MMM, 1991). The report details a methodology for the integration of BMP planning into the municipal planning process, a BMP selection process and recommendations for the BMP design methodology. It provides estimates of BMP capital costs, maintenance costs and gives recommendations for research and monitoring studies. The Phase 2 project started in 1992. The goal is to develop both a hardcopy version and a computer expert system version of the manual. It will provide step-by-step guidance at the planning and design stages for consultants. It will also provide guidance for staff of regulatory agencies.

It is not sufficient just to build SWM facilities. They need to be properly operated and maintained. They also need to be monitored to ensure that they are operating as designed. Work must be continued to monitor improvements (or impairments) in the environment achieved by the implementation of SWM facilities. The data collected would be useful in making improvements in BMP design.

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CHAPTER 15

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CHAPTER 16

Stormwater Quality and Quantity Management: Legal Considerations

W.J. Snodgrass

ABSTRACT

This paper reviews the legislative basis for stormwater quality control and for protection of ecosystems from the influences of urbanization. It then presents examples of case law which influence the development of stormwater quality management practices.

It first presents the causes of environmental degradation, a list of parameters whose measurements characterize environmental quality, and then summarizes the specific ways by which urbanization and stormwater cause environmental degradation.

Urbanization which causes environmental degradation through spatial (indirect) impacts of building the city and releasing stormwater have many pieces of legislation for controlling it. Twelve acts are reviewed, including the Planning Act, Municipal Act, Ontario Water Resources Act, Fisheries Act, and Environmental Protection Act. Representative policies such as stormwater quality control guidelines and MISA, developed under these acts are then reviewed and their applicability to stormwater quality control pointed out. The role that each act has in the protection of specific ecosystems or human concerns (e.g., fisheries and their habitat, groundwater resources, surface water quality, etc.) as well as in terms of water quality control and water quantity management are summarized.

A few examples of relevant case law and regulatory body decision making are reviewed and their implications for design and implementation of stormwater quality control discussed. The Scarboro Golf and Country Club case, reviewed elsewhere in this volume (Chapter 14) suggests that each BMP facility should be approved under the Ontario Water Resources Act. This may take the form of designating each facility as a "sewage works" and operating it under a certificate of approval. This paper suggest that an applicable design standard would be "state-of-the-art".

This paper also presents an Ontario Municipal Board hearing which points out the need to conduct a thorough technical analysis and cumulative effects analysis (watershed planning study) to establish the carrying capacity. If such analyses are not presented adequately, the Board will refuse to render a decision.

As well, government agencies may use court proceedings to achieve compliance. Use of Section 16 of the OWR Act ("a discharge may impair") is one particularly relevant section.

16.1 Objectives of Paper

The objectives of this paper are to outline the legal basis for stormwater quality control and to present examples of application from a policy/regulation promulgation point of view and from a case law point of view. The legal considerations are directed to an ecosystem framework. Protection of water quality and biological habitats in riverine receiving waters is the major focus used to present the need for stormwater quality management.

16.2 Causes of Environmental Degradation

There are a variety of ecosystems, environmental resources and human uses of these resources which may require protection in a watershed. They include the following:

1. Terrestrial resources particularly on hills and table lands and in river valleys which provide habitat for animals and wildlife and which cleanse runoff and protect surface water supplies from erosion.

2. Drinking water, derived from both groundwater sources and surface water supplies.

3. The aquatic ecosystem (benthos, algae, zooplankton, macrophytes, wetlands, fish) of the riverine and lacustrine surface water bodies in the region.

4. The aesthetics of the landforms (wooded valleys and hills) and waters of the region.

5. Human safety in river valleys prone to bank erosion and flooding.

6. The soils of the region.

7. The air resources of the region,

8. Groundwater Protection for Human Uses other than drinking water.

9. Birds and Wildlife.

10. Recreational Uses of Surface waters.

11. Tableland Wetlands, (not connected to streams and lakes)

These environmental resources, the environmental parameters which describe the "quality" of each of the environmental resources/human uses and the major causes of degradation of each of the environmental resources are summarized in Table 1.

The environmental parameters listed in Table 1 can be used to assess the state of environmental quality of each resource/human use. Most of the environmental parameters are biological or chemical in nature. Only a few are physical in nature (e.g., turbidity, colour, odour, clarity, peak flow rate, riverine flow rate for "flood protection"; groundwater flow for "drinking water supply"). Most parameters can be measured quantitatively using conventional measurement methodologies.

In a legal framework, regulatory agencies and courts require both environmental quality parameters which can be measured and criteria by which the state of environmental quality can be assessed. Table 1 can be used in an overview way to ensure that appropriate quality parameters are selected.

TABLE 1: ECOSYSTEM AND HUMAN BASIS FOR ENVIRONMENTAL MANAGEMENT AND CONTROL

Environmental Resources and Human Uses	Key Parameters	Causes of Environmental Degradation: Major Pollution Sources	Causes of Environmental Degradation: Other Causes of Environmental Degradation
1. Terrestrial Resources - Trees	Atmospheric Acidity - SO_2 - NO_x • Municipal Heating • Individual Home Heating • Industrial Heating • Transportation	• Transboundary Air • Pollution • Power Production • Dead Tree Cutting • Soil Degradation promoting Al release and soil erosion	• Diseases • Monocultures of Trees • Tree Dieoff
2. Air Resources	• CO_2, • CH_4, CO • Clarity (Particulate) • TSP • Ozone • Hydrocarbons • H_2S	• Power Generation Fuel • Home Heating Fuel • Cows (CH_4)	• Transboundary Transport • Marsh Releases
3. Drinking Water			
a) Surface Drinking Water	Fecal Coliforms Aluminum Suspended Solids	• Untreated Sewage • Industrial Discharges • Agricultural Wastes	• Watershed Erosion • Weathering of Al from soils
b) Groundwater General	Radon Nitrates, Nitrites Fecal Coliforms (Iron)	• Agriculture (Manure, Fertilizers) • Sewage	Natural Soil Weathering (Rn-222)
c) Groundwater - Special Concerns (Site Specific)	COD Ammonia Trace Metals Persistent Synthetic Organic Chemicals	• Landfills • Hazardous Waste Dumps • Industrial Sites • Military Dumps • Gasoline Stations	
4. Groundwater Protection In General	• All Water Quality Paramters • Landfills • Sewer Leakage Industrial Sites Urban Areas Agriculture - Fertilizers - Herbicides/Pesticides - Manure Piles	• Spills • Hazardous Wastes	• Excessive Pumping • Aggregates/Quarries

TABLE 1: ECOSYSTEM AND HUMAN BASIS FOR ENVIRONMENTAL MANAGEMENT AND CONTROL

Environmental Resources and Human Uses	Key Parameters	Causes of Environmental Degradation: Major Pollution Sources	Other Causes of Environmental Degradation
5 Aquatic Ecosystem (Fishery)			
5a) Chemical Habitat and Toxicity	Dissolved Oxygen Ammonia Copper, Zinc Petroleum (BTX)	• Sewage Discharges • Urban Commbined Sewer & Stormwater Overflows • Industrial Discharges • Spills of Petroleum Products	
5b) Physical Habitat - River	Temperature Suspended Solids Total Phosphorus	• Heated discharge • Sewage Discharges • Stormwater Overflows • Agriculture Discharge	• Stream Channelization • Canopy Destruction • Low Baseflow • Loss of Riffle/Pools
5(c) Fish Quality (Contaminant Concentration in Fish)	Mercury PCBs Dioxin Mirex	• Industrial Discharges • Transformer Oils	• Natural Cycling of • Contaminated Air
(d) Fish Food - River	• Index of • Biological Integrity • Total Phosphorus	• Sewage Discharge • Stormwater Overflows • Agricultural Discharges	• Destruction of Food Web • Canopy Destruction
(e) Lake Aquatic Ecosystem	Total Phosphorus	• Sewage Discharges • Agricultural Runoff • Urban Stormwater Overflows	
6. Aquatic Sediments	• Trace Metals - Zn - Cu • PAHs • PCBs • Acid Volatile Sulphide	• Industrial Spills	• Eutrophication
7. Human Uses of Soils - Growing Crops - Real Estate Transfer - Children Playing - Groundwater Protection	• Hydrocarbons • PAHs • Trace Metals - Hg - Pb • Pesticides • Herbicides	• Industrial Spills • Industrial Products Waste Handling • Spraying Crops	
8. Aesthetics	• Landscape Values • Water Characteristics - Turbidity - Colour - Odour	• Sewage • Agricultural Runoff • Urban Stormwater	• Denuding of Vegetation • Streambank Erosion

TABLE 1: ECOSYSTEM AND HUMAN BASIS FOR ENVIRONMENTAL MANAGEMENT AND CONTROL

Environmental Resources and Human Uses	Key Parameters	Causes of Environmental Degradation: Major Pollution Sources	Causes of Environmental Degradation: Other Causes of Environmental Degradation
9. Human Safety			
- Flood Control	-- --	• Urbanization • Deforestation	
- Erosion Control		• Suspended Solids	• Urbanization
10. Recreation - Swimming	• Fecal Coliforms • Turbidity • Chlorophyll a	• Sewage • Agriculture • Stormwater	
- Boating	• Total Phosphorus	• Overflows	
11. Birds and Wildlife			
a) Habitat	- • Atmospheric Acidity	• Destruction of Forests	
b) Acute Toxicity	- -	-	
c) Impairment - Contaminants Levels)	Mirex Industrial Urban Agriculture	Transboundary	
12. Wetlands	• COD • Metals • Industrial Discharges • Engineered Wetlands to Polish Sewage	• Contaminated Groundwater • low Groundwater tables	• Urbanization • Cows
13. Irrigation	• Metals • Polluted Groundwater	• Polluted Streams withdrawal	• too much water
14. Water Transport	• SS • Sediment Accumulation • Contaminated Sediments	• Watershed Erosion • Streambank Erosion	

POLLUTION CONTROL IMPLEMENTATION

The causes of environmental degradation are divided into two categories in Table 1:

- major pollution sources, and
- other causes

The major pollution sources include:

- surface water discharge from point sources
- stormwater runoff from urban and rural sources
- air emissions from point sources
- transboundary transport of polluted air
- soil and groundwater contamination from point sources (landfills, hazardous waste dumps), and
- diffuse sources such as agricultural activities which pollute surface water and groundwater.

Most of these pollution sources are associated with human activities in the watershed, except for air pollution (as measured by atmospheric acidity, - SO_2 and NO_x) which is often dominated by transboundary sources.

On a worldwide basis, water pollution and pollution control efforts in urban areas have resulted in 5 or 6 threshold levels of residuals in aquatic systems dependent upon the degree of pollution control. These thresholds include:

- open sewers and ditches contain untreated human sewage and industrial effluents (e.g., as found in large cities in the developing world) draining to receiving waters;

- undersized or inadequately operated wastewater treatment plants;

- adequately sized and operated wastewater treatment plants for dry weather flow;

- wastewater treatment of dry weather flows and partial treatment of combined sewer overflows;

- completely separated sewer systems without water quality based BMPs on the stormwater system; and

- BMPs located on all urban stormwater systems.

In addition to pollution caused by discharges to surface water and groundwater and air emissions, a variety of other human activities cause environmental degradation. These include:

i) land uses such as
   - agriculture, which promotes overland and stream bank erosion;
   - industrial land uses which cause soil and groundwater pollution; and
   - urbanization;

ii) stream channelization which destroys stream canopy and/or wetlands;

iii) degradation of a forested ecosystem in the watershed due to feed back between pollution sources and other causes of loss of forest cover.

In several watersheds around the world, these "other causes of environmental degradation" are more significant that are point and non-point sources of pollution. Examples include the conversion of forested lands into agricultural, urban, or other land uses, leading to erosion of soils, changes in local weather patterns and destruction of wildlife habitat.

Hence, for use in a legal framework, the reader should ensure that the cause of degradation can be clearly linked to a state of non-compliance in a technical sense.

16.3 Impact of Urban Stormwater Upon the Environment

The previous section has provided an overview of the major causes of environmental degradation and the myriad of parameters available to describe environmental quality. It suggests a perspective that urban stormwater runoff collected in separate sewer systems and its chemical constituents, are only one component of all the factors influencing environmental quality. Combined sewer overflows which represent a blend of urban stormwater and sanitary sewerage generally is thought to contain residuals one order of magnitude higher than separated stormwater discharges.

But stormwater runoff can be the dominant cause of ecosystem degradation in riverine systems due to flow effects. It is the major source of water pollutants in urban receiving waters not influenced by water pollution control plant (WPCP) discharges. Storm sewers make receiving waters susceptible to the effects of spills of petroleum by products and other toxic substances.

As noted in the previous paper, regulating controls are a major method for protecting water quality and the health of the ecosystem in addition to pollution prevention, pollution control, and land use control. To properly use regulatory controls, one must understand the principal variables which influence the impacts of stormwater on the environment and design legislation, land use planning, regulations, policies, and enhancement activities to address each of these variables.

The major variables include:

- density of development
- site design
- pathways transporting stormwater runoff (i.e. are the outlets to a particular watershed)
- provision for BMPs to provide protection, and
- residuals.

This paper now reviews the legal basis for managing all of these variables.

16.4 Definition of Stormwater

There are a variety of definitions for stormwater to be considered in a legal context. Guidance is given in both with case law and under applicable legislation. For example, the General Effluent Monitoring Regulation (Ontario Regulation 695/88) defines stormwater discharges as follows:

- "storm event" in relation to a plant means rainfall or a series of rainfalls on an operating day that in total exceeds five millimetres...;

- "storm water" means run-off from a storm event or thaw that it discharged from a developed area of a plant directly or indirectly to a surface watercourse;
- "storm water effluent stream" means storm water that flows through an open or closed channel;
- "storm water sampling point" means a location in a storm water effluent stream situation before the place of discharge to a surface watercourse;
- "surface watercourse" means a lake, river, pond, stream, reservoir, swamp, marsh or surface drainage works; and
- "thaw" in relation to a plant means the melting of snow or ice sufficient to create an effluent stream at the plant.

These definitions allow one to differentiate between stormwater discharges and the other effluent monitoring points from an industrial site or wastewater treatment plant such as process effluents, emergency overflows, once-through cooling water, and waste disposal sites.

16.5 Review of Legislation Influencing Stormwater Quality and Quality Control

There is a wide range of legislation in existence which is, or could be used to control the quality of stormwater released to surface waters from urban areas.

The key steps in understanding the review are the following:

- legislation;
- policies/documents used to implement the legislation;
- regulations and programs promulgated under the legislation;
- procedures used to attain implementation of the policies, such as:

- review of applications for new developments and programs,
- funding available to assist implementation,
- use of civil and criminal courts by governmental agencies or affected parties to remediate harm or to obtain acceptable behaviour.

This section now reviews relevant legislation. This section draws particularly upon a recently completed watershed study (BEAK *et al.*, 1991A). Examples of a few policy initiatives derived from this legislation are presented in Section 16.6, while international aspects is described in Section 16.7. Procedures involving the courts and other regulatory panels are then discussed in Section 16.8.

1. Planning Act/Municipal Official Plans

Municipalities are required to develop Official Plans under the authority of the **Planning Act**. Official Plans provide for control of land use and the way that land is developed. Government agencies review development plans and attach technical requirements as a condition of draft plan approvals. Once official plans have been adopted by a municipality, development proposals must comply with the requirements.

2. The Municipal Act

The **Municipal Act** provides for municipalities to own and operate municipal services such as storm drainage systems. Under this act, municipalities can control the substances discharged to sewers and control the design and operation of facilities such as storm drainage and stormwater management systems through enforceable bylaws.

3. Conservation Authorities Act

The Conservation Authorities Act is the legislative authority for establishing Conservation Authorities with their attendant authority for regulating fill, construction and alteration to waterways, flood lines and fill lines, and erosion control is evolving and may need revision in the future. The relationship between various levels of watershed planning and municipal planning process shown in Figure 1 of Chapters 2 and 17 of this volume.

4. The Lakes and Rivers Improvement Act (Ontario)

This Act, administered by the Ministry of Natural Resources regulates the use of and improvements to waters of the lakes and rivers of Ontario. Items covered include: (i) public rights in or over such waters; (ii) interests of riparian owners; (iii) management of the fish, wildlife and other natural resources dependent on such waters; and (iv) the natural amenities of the waters, their shores and banks.

5. Environmental Protection Act (Ontario)

The purpose of the Environmental Protection Act (EPA) is to provide for the protection and conservation of the natural environment. It prohibits "discharge into the natural environment of any contaminant...." (which is anything that may "impair the quality of the natural environment for any use that can be made of it......"). It provides for regulating private sewage disposal, littering, and spills.

6. Ontario Water Resources Act

This Act, administered by the Ministry of the Environment, provides for the protection of ground and surface water, and controls the development of water and sewage works. Storm sewers and stormwater control ponds require approval as sewage works under this Act. Operators of sewage works and waterworks must obtain a Certificate of Approval for the operation of the works. The Ministry has delegated approval authority to the regional municipalities for simple storm sewer systems, but stormwater quality control ponds remain the Ministry's responsibility. Temporary sediment control ponds are technically sewage works; however, only permanent ponds typically require sewage works approvals.

7. Environmental Assessment Act (Ontario)

This Act requires an environmental assessment of certain undertakings or development projects in the public sector. The construction of storm sewer systems by private developers follow a simplified review, if a public agency (the municipality) will ultimately own the system. The more complex the project, the more detailed the review that takes place.

8. Fisheries Act (Canada)

This Act provides for the conservation and protection of fish and waters frequented by fish, and for the proper management and control of inland fisheries. The Act contains two important prohibitions: against the disruption or destruction of fish habitat; and against the deposit of deleterious substances in waters frequented by fish.

Policies developed under the Act mandate three significant goals: (i) a No Net Loss principle for maintaining fish habitats through adoption, (ii) rehabilitate fish habitat, and (iii) develop new fish habitat.

9. Special Planning Areas

Special Planning Areas are set up under special legislation. Examples include the Niagara Escarpment and the Oak Ridges Moraine. The Ontario government set up the Niagara Escarpment Commission (NEC) through an Act of the provincial legislature. The Oak Ridges Moraine Area is presently controlled through an Expression of Provincial Interest by the Ontario Government and Implementation Guidelines for the review of official plans and amendments, zoning bylaws and amendments, plans of subdivision, and commercial and industrial operations. These guidelines are reviewed below.

10. Forestry Act, Woodlands Improvement Act

Reforestation may be achieved through a variety of programs under the Forestry Act and Woodlands Improvement Act administered by the Ministry of Natural Resources.

11. Trees Act

Tree bylaws may be passed by municipalities, under the Trees Act to regulate and control the destruction of trees on private land.

12. Summary of Applicable Legislation

Applicable legislation should be examined from the point of view of the environmental resources and human issues being protected and the mode of the impact upon these issues due to stormwater runoff. Applicable legislation protects the environment from the following modes of impact:

- legislation which controls development through land use planning. This controls spatially related perturbations due to encroachment by urban areas and due to the construction of stormwater pipes and BMPs.
- legislation which protects natural stream channels by controlling the impact of released flows upon the proposed integrity of the stream channel and habitat for riverine biota (e.g., benthos, fish). This is a pathways impact.
- legislation which protects riverine biota and dissolved constituents from impacts of chemical constituents released by stormwater systems. This is a pathway impact.

A review of enabling legislation for managing various environmental issues subjected to the spatial impacts described in Chapter 17 is given in Table 2. The applicability of the 12 acts presented above is presented for seven environmental issues, including groundwater protection, habitat, natural features, and surface water quality. The applicability of each act for managing the specific effects of urban stormwater systems (flow, chemical, and spatial) are summarized in Table 3 using the following three categories:

- water flow impact
- water quality/toxic impact
- spatial impact

The key agencies with a significant role in water management are also given in Table 3. The Conservation Authorities and MNR have key responsibilities for Flow Management.

The responsibility for water pollution control lies largely with the Ministry of Environment. Key legislation includes the Ontario Water Resources Act, and the Environmental Protection Act. The Fisheries Act enforced by the Ministry of Natural Resources also can be used to control water pollution. In urban areas, local municipalities have jurisdiction over land development and own an operate drainage and treatment services, under the Municipal Act and the Planning Act. The incorporation of

TABLE 2: APPLICABLE LEGISLATION FOR IMPLEMENTING ENVIRONMENTAL CRITERIA

Legislation	Oak Ridges Moraine	Groundwater Protection	Aquatic Communities	Wetlands ESA, ANSIs	Surface Water Quality	Agriculture	Hazard Lands	Recreation
Planning Act/ Municipal Official Plans	X	X	X	X		X	X	
The Municipal Act	X	X	X	X	X	X	X	X
Conservation Authorities Act							X	
The Lakes and River Improvement Act (Ontario)			X		X			
Environmental Protection Act (Ontario)		X		X				
Ontario Water Resources Act		X	X		X			
Environmental Assessment Act	X	X	X	X	X		X	X
Fisheries Act (Canada)			X		X	X		
Special Planning Areas	X							
Forestry Act, Woodlands Improvement Act				X		X	X	
Trees Act				X		X	X	

TABLE 3: APPLICATION LEGISLATION FOR WATER MANAGEMENT AND STORMWATER IMPACTS

Legislation	Main Impacts	Lead Responsible Agency
Municipal Act and Regional Government Act	All 3 modes of impacts	Municipality
Conservation Authorities Act	Primarily water flow impact	Conservation Authorities
Planning Act	Primarily Spatial Impacts	Ministry of Municipal Affairs
Lakes and Rivers Improvement Act Fisheries Act Conservation Authorities Act.	Primarily water flow impact	Ministry of Natural Resources
Ontario Water Resources Act Environmental Protection Act Environmental Assessment Act	Primarily water quality impact	Ministry of Environment
Highway Improvement Act	All 3 modes	Ministry of Transportation
Drainage Act	Primarily water flow impact	Ministry of Agriculture and Food

environmental requirements into the Official Plans of municipalities is also becoming an effective means for protection.

16.6 Use of Policy Initiatives to Assist Stormwater Quality Control

This section presents examples of initiatives undertaken by the Government of Ontario which will assist stormwater quality control, but which have no direct legal standing without specific implementing legislation or using existing legislation.

16.6.1 Guidelines on Erosion and Sediment Control for Urban Construction Sites (1987)

These guidelines were prepared jointly by several ministries and municipal bodies. They are implemented for example, by a municipal bylaw.

16.6.2 Interim Stormwater Quality Control Guidelines for New Development (1991)

The goal of these guidelines is the protection and enhancement of pre-development hydrologic and water quality regimes. An early version and the latest version of these guidelines are given in Chapters 2 and 3 respectively. They can be implemented as requirements in official plans or bylaws of municipalities, or attached as approval conditions by government agencies.

16.6.3 Strategic Plan for Ontario Fisheries (SPOF)

This plan is the policy description for Ontario Ministry of Natural Resources (MNR) program. The objectives of SPOF are administered through fisheries management plans at the District level in the MNR organization. The legislative authority comes from the delegated responsibility under the Fisheries Act and from the Lakes and Rivers Improvement Act.

16.6.4 Wetland Protection Guidelines (1984)

The Ministry of Natural Resources introduced guidelines that represent the provincial government's concern for wetlands and wetlands management. Wetlands are classified into seven classes. Designation of the wetlands and controls on development are to be implemented through the official plans of municipalities.

16.6.5 Fill Regulations for Wetlands Management

Wetlands may also be protected through **Fill Regulations** administered by a conservation authority.

16.6.6 MISA Program

The Municipal-Industrial Strategy for Abatement (MISA) program has as its goal the "virtual elimination of all persistent toxic contaminants from all discharges into Ontario's waterways". The program is being implemented by a series of Monitoring Regulations and Effluent Limits Regulations made under the Environmental Protection Act.

The control of stormwater discharges from industrial and municipal plants is one of the measures required to be taken to meet the goal of MISA. Their control will be detailed in a technical document entitled Guidelines for carrying out a Stormwater Control Study (SWC).

The requirement to carry out an SWC study is stated in effluent Limits Regulations and apply to sites which have direct discharges of treated process effluents to surface waters. The Regulations do not apply to indirect dischargers to municipal sewer systems. Consequently, the Guidelines are to be used by:

- the dischargers (industrial or municipal plants), and
- Ministry of the Environment as the regulatory agency reviewing and approving the plan implementation actions.

Technology based limits are being imposed on direct dischargers, based on information collected in a series of monitoring regulations for each industrial sector. Many direct-discharger industries release storm drainage to surface waters which, if contaminated, may also be controlled through application of technology based limits.

16.6.7 Policies Developed Under the Ontario Water Resources Act

The publication "Water Management ; Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment" (the Blue Book) outlines the approach to water quality and water quality control. Policies are stated with respect to the observed water quality in a water course.

Policy 1. In areas with water quality better than the objectives; water quality shall be maintained at or above the objectives.

Policy 2. In areas with water quality not meeting the objectives, the water quality shall not be degraded further and all practical measures shall be taken to upgrade the water quality to meet the objectives.

These policies and criteria provide the foundation by which legal bodies such as courts may interpret the requirements of the OWR Act.

16.7 International Agreements and Laws

16.7.1 The Great Lakes Water Quality Agreement

The governments of Canada and the United States have entered into an agreement in 1978, updated in 1987, to protect the Great Lakes. One part of the agreement sets target loads for phosphorus discharged to the Great Lakes. In recent watershed studies, suggestions of allowing no net increase in phosphorus loadings from urban stormwater sources has been suggested as a target.

16.7.2 UNESCO

The United Nations (UNESCO) has named the Niagara Escarpment as a World Biosphere Reserve. The designation has no special status under international law which is enforceable in Ontario.

16.8 Recent Legal Findings Related to Stormwater

There are a variety of findings which have a potential legal content which will influence stormwater management in Ontario. Two cases are reviewed here:

- the Scarborough Golf and Country Club case, and
- a project presented before the Ontario Municipal Board.

Then the potential impact of enforcement through using the court system is reviewed.

16.8.1 Potential Municipal Liability for Stormwater

The potential liability of a municipality for installation of a stormwater system to remove runoff from near homes and to control both patterns and volumes of runoff and the water quality have been recently addressed in a court case where both case law and legislative statutes were used as a basis for the suit and as a basis for defending the municipalities.

The issues brought up at the trial and their legal basis, the decision in the judgement, and the decision from the appeal are given in Price and Tran (1992). Legal issues pursued in this court proceedings include (i) riparian rights concepts as developed by case law; (ii) the applicable provisions of the Ontario Municipal Act; and (iii) applicable provisions of the Ontario Water Resources Act.

1. <u>Riparian Doctrine</u>

The decisions largely revolved around quantity and erosion issues, but have potentially far-reaching implications for stormwater quality control. Riparian issues centred upon interference, nuisance and negligence. Pertinent legal language on these issues include:

- On water quality - "Generally speaking, a riparian owner has the proprietary right to have the water in the natural watercourse flow to him in its natural state, neither increased nor diminished in quantity or quality. He is also entitled to use it for domestic and natural purposes".

- On interference - "There are many types of work that have been held to constitute interference with the natural channel of a stream, such as deepening the channel, removing silt or gravel, straightening the course of a stream, etc."

- On nuisance - "the unreasonable interference with another's use or enjoyment of his land. In other works, a nuisance can consist of material injury to property or the creation of a sensible discomfort to the property owners."

Hence, riparian doctrine infers that the quality of the water must be whatever it was in its natural state. Further it should be of such quality to permit domestic or natural purpose.

2. The Defence of Statutory Authority - Municipal Act

In respect of the allegations of nuisance, the City had argued that the Municipal Act authorized construction of the drainage system which resulted in the nuisance to the Golf Club. The City argued that this gave them a defence of statutory authority.

For such a defence to succeed Mr. Justice Cromarty pointed out that a defendant must prove that the nuisance it created was the "inevitable result" of doing something which has been authorized by statute. Statutory defence under the Municipal Act was rejected because although the Act gave the City the "power to build and maintain" a stormwater drainage system, it did not contain a "direction to adopt [the] particular method" of drainage which resulted in the nuisance.

3. The Defence of Statutory Authority Under the Ontario Water Resources Act

The Defence of Statutory Authority under the OWRA was not tested in the Scarborough Golf and Country Club case. Ultimately, the municipality desires to have a defence of statutory authority under section 30 of the *Ontario Water Resources Act* for any damage caused by the urban area and associated infrastructure, provided the municipality is not negligent in the design of its stormwater management systems and damage to downstream users is unavoidable regardless of the design or approach adopted by a municipality.

A review of appeal court's findings provides the following pertinent points which should be considered:

(i) s.30 of the OWRA "does not bar a common law action but the Authorities referred to above establish that specific statutory authority, such as here provided to these sewage schemes, does protect the City absent negligence in implementation of the approved scheme and if the resulting damage is inevitable ...".

(ii) as long as stormwater quality works have been designed in a non-negligent fashion pursuant to a statutory authority, and the downstream nuisance is an inevitable result of the proper exercise of that authority, municipalities may have a defense of "statutory authority".

(iii) damage must be inevitable before the defence of statutory authority is granted.

(iv) the evidence will have to go beyond the simple question of whether or not approvals have been issued under the OWRA to include a detailed analysis of each of the successive approvals, discretion available, and the resultant inevitability of the damage.

(v) other causes of the damage not protected by s.30 of the OWRA, such as increases in run-off volume due to increased pavements and buildings, will have to be considered as well.

Price and Tran (see Chapter 14) suggested that technical criteria for the defence of "statutory authority" should include (i) stormwater quality control works have been designed using the latest scientific knowledge, and (ii) construction, maintenance and operation have been approved under the O.W.R. Act.

Implications

This case raises the following question to this author: should municipalities seek a designation of each stormwater outlet and/or suite of BMPs as a "sewage works" and hence should these works also then be covered under a Certificate of Approval designation to protect the municipality under this case law.

As well, the appropriate design standard was of concern in this court case. In the case of Scarborough Golf and Country Club v. City of Scarborough (1985), Mr. Justice Cromarty stated:

> "Certainly there was no evidence nor was there argument made that the particular drainage system employed was the only or the best system that could be devised under the circumstances or that a system could not be devised that avoided causing material injury to the plaintiff."

This is with reference to sewers installed before attempts were made to manage stormwater runoff patterns. Subsequently, as noted in Chapter 14, stormwater quality management has become a concern.

But, the test of "latest scientific knowledge" suggested by Price and Tran (1992) as an appropriate design standard, may be excessive. Rather, a test of "state-of-the-practice" or "state-of-the-art" may be more appropriate. State-of-the-practice is often described in manuals of practice (MOPs) and may even be codified (e.g., Natural Building Code). It can be thought of as a standard approach which a designer has used fifty or sixty times previously. For urban stormwater quality control, state-of-the-practice is usually inadequate or not available because the objectives for protection have so changed in the past five to ten years that a standard state-of-the-practice does not exist.

State-of-the-art may be a design which has been built in another location and applicable at the particular site, but requires refinements for that site or special considerations. It may actually be a new design which has not been built elsewhere. A state-of-the-art design standard is difficult for approval agencies to review. However, state-of-the-art would appear to be an appropriate standard for consideration. Accordingly, for municipalities and for other builders of such facilities, it is suggested that the following requirements be considered in designing such facilities.

- Define the goals for protection (i.e., the ecosystem basis or human basis).

- Define the environmental guideline necessary to achieve these goals. Where possible, define environmental quality and quantity criteria in qualitation or qualitative terms. These should be based upon the results of watershed or

subwatershed studies. Where such studies have not been carried out, the guidelines could be based upon consultation with the CA, the MOE, the MNR, municipal planning departments, an identification of the resource to be protected (e.g., warmwater, coldwater fishery, wetland) and consideration of MOE Blue Book policies (see Chapter 3 for further considerations).

- Define the objectives for stormwater quality, stormwater volume control, and ecosystem protection for runoff from the drainage area.

- Lay out a conceptual sketch of the drainage area, of Best Management Practices to be implemented throughout the drainage area, and of the location of specific BMP facilities (i.e., wet ponds, infiltration devices).

- Carry out an impact assessment and select appropriate combinations of BMPs which will achieve the objectives for stormwater quality and quantity.

- Detail those facilities which are state-of-the-art. Document data which shows facets of the facility which have been built elsewhere. Document which facets have not been built elsewhere and hence which may not perform up to expectations.

- Ascertain that the proposed conceptual layout meets requirements for stormwater quality management which are evolving under the MISA program. Document this check. The documentation would ensure that the proposed facilities meet the legal test of "state-of-the-art", even if subsequent analysis in the future finds that the facilities are inappropriate or deficient.

- Check with a legal authority to ensure that the above steps are appropriate procedures for building state-of-the-art facilities.

- Apply for a Certificate of Approval for the BMP facilities under the Ontario Water Resources Act.

- Develop an implementation and monitoring plan, and an auditing plan.

- Construct the facility.

- Implement the monitoring and auditing plan and other requirements of the C of A.

16.8.2 Ontario Municipal Board (OMB) Example

This section briefly documents a recent case concerning the adequacy of technical analysis in support of development applications before the OMB (Lorrie Pella personal communication).

The proponent for a development in Belfountain applied for an Official Plan Amendment to build a subdivision. A key part of the stormwater management was to use natural depressions for infiltration.

The Ministry of Natural Resources took the position that a carrying capacity analysis was required and that a holistic study must be undertaken and completed, rather than the submission of separate study components which were not related to each other in the study report. In particular, the MNR insisted that the following issues be integrated into a holistic study report:

- stormwater management,
- groundwater infiltration and exfiltration/baseflow,
- septic system impacts, and
- drinking water from groundwater sources.

As well, they concluded that the technical analysis presented to date was inadequate to support the application since supporting calculations for a net effects analysis had not been made. The proponent argued that such an analysis and approval was more appropriate at the draft plan approval stage for the subdivision.

The proponent made its presentation of the concept for stormwater management to the OMB without the investigation requested by the MNR. The Board stopped the case with the proponents testimony without taking further evidence making a finding of 'Non-Suite'. This meant that the Board felt that the evidence and analysis by itself was insufficient and hence that the Board would not consider the application further, until the required evidence was available.

This points out several needs with respect to stormwater management.

1. The review agencies are requiring that a higher level of technical analysis and a more comprehensive integration of component parts be carried out at an earlier stage of the approval process.

2. Clear, implementable criteria for water quality, water quantity, and ecosystem protection are required by proponents for official plan or secondary plan approvals prior to finalization of specific site plans and layouts.

   One can establish the appropriate environmental quality parameters by review of Table 1 presented in this paper. But one must establish the criteria for protecting the environment as a separate task.

   In addition, a small amount of crystal-ball gazing would suggest that soft BMPs, land use planning and site density factors in conjunction with the proper suite of hard BMPs may be required by the OMB in the foreseeable future with justification that these BMPs will protect the environmental resources and human uses of water, prior to approval for Official Plans amendments on Secondary Plans.

3. Watershed plans and subwatershed plans in support of secondary plans are needed everywhere.

The question of the basis for setting these criteria for water quality, water quantity, and ecosystem protection must be answered. Ideally, they should be established after a watershed management plan is established because this provides the basis for settling watershed goals and objectives to protect the environmental and human value systems, for integrating these various value systems and for prioritizing conflicting value systems. To be reasonably specific, subwatershed plans are also required for setting environmental and water management criteria.

For areas of Ontario which have not developed watershed plans, the question of who should set the criteria awaits future resolution. As a result of our several studies, we would suggest that the proponent, with the support of qualified proper environmental/ecosystem professionals, should canvas regulatory authorities and propose criteria as a part of the planning process. The success of their application will, then

depend in part upon the adequacy of these criteria for protecting the environment and the adequacy of the proposed site of BMPs for achieving the proposed criteria. This approach is implicit in the steps suggested above for implementing state-of-the-art facilities as a result of the Scarborough court case.

16.8.3 Use of Court Cases to Achieve Stormwater Management

In addition to many legal and issues which have been raised above, the use of the courts to induce desired behaviour is being used more frequently by the Ontario Ministry of the Environment, particularly for industrial discharges. One avenue is to charge the industry and the responsible official with an infraction under the Ontario Water Resources Act. One charge being used in several cases is that a discharge "may impair the environment".

The extension of the concept to stormwater management is foreseeable, especially for spills and other discharges which impact the receiving water, provided the party causing discharge can be established. This charge may be applicable equally to industry or municipalities as owners of the sewer systems discharging to the environment.

In applying this charge, the existing cases seem to centre particularly upon the term "may impair". It has both technical and legal aspects for which resolution in case law is required.

The definition of the term "may impair" is derived from Section 16 of the *Ontario Water Resources Act.*

Section 16(1) states:

> Every person that discharges or causes or permits the discharge of any material of any kind into or in any waters or on any shore or bank thereof or into or in any place that may impair the quality of the water of any waters is guilty of an offense.

This subsection is qualified by Section 14 of the Act which states:

> Under section 15, 16, 18 and 19, the quality of water shall be deemed to be impaired if notwithstanding that the quality of water is not or may not become impaired the material discharged or caused or permitted to discharged or any derivative of such material causes or may cause injury to any persons, animal, bird or other living thing as a result of the use or consumption of any plant, fish or other living material or thing in the water or in the soil in contact with the water.

Several issues exist. These issues which have varying degrees of case law behind them, include:

1. Does the Crown have to show actual impairment of the quality of the subject water?

2. Is there a *de minimis* range whereby the amount or concentration of the material is so negligible that it could be said that the material could not impair the quality of the water?

3. Can the existing conditions of the water be taken into account in the determination of impairment?

The case law upon these three legal and technical issues is evolving. Some case law is persuasive on the first issue, but not on the next two. Accordingly, this author does not attempt to summarize this case law at this point in time.

16.9 Acknowledgements

This paper is based upon several recent studies that the author has been involved, as referenced in the next section. Special mention should be made of Mr. M. Jeffries, Ms. L. Pella, Mr. D. Weatherbe, Dr. Karl Schiefer and Mr. D. Maunder who influenced the development of the writing of material contained in this paper.

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CHAPTER 17

Proposed Environmental Guidelines for Land Use Planning in New Urban Developments

W.J. Snodgrass

ABSTRACT

This book has focused upon stormwater quality control and means for implementing these controls. This one of the four methods for stormwater quality management, which are: pollution prevention, pollution (stormwater quality) control, land-use control and regulatory control.

This paper examines land use controls as a means for enhancing stormwater quality and protecting key ecosystems from the impacts of urban development. It indicates that land use controls (site density, site layout) will become increasingly important in the future to protect water quality.

This paper reviews the modes of urban development impacts upon ecosystems which include spatial effects (e.g. encroachment on key habitats or natural features), pathways effects, social effects, and cumulative effects. It points out that land use planning is a major approach for protecting key habitats from the spatial effects of urbanization.

Environmental guidelines in the form of areas of no development, environmental research areas, areas requiring site controls, and areas of environmentally friendly development are proposed for land use planning. These guidelines are proposed for the following issues and resources:

- aquatic communities (fisheries),
- wetlands, ESAs, ANSIs and other natural features,
- surface water quality and recreation issues,
- groundwater systems,
- hazard lands, and
- agricultural lands.

As well, additional technical criteria for reviewing pathways impacts are included where appropriate.

These guidelines should be used as a framework for ecosystem protection in urbanizing areas and rigorously tested prior to their adoption in specific study areas.

These guidelines are proposed. They have not been formally or informally reviewed by any agency of the Province of Ontario. Their publication in this book does not represent an endorsement by any such agency or by any municipal government or other legal authority.

17.1 Introduction

17.1.1 Stormwater Quality Management

Stormwater quality management has resulted from increasing pressure on government approval agencies to respond to what the public perceive as severely degraded aquatic environments in urban areas. Inadequate controls on lands undergoing change from rural or natural to urban are viewed as primary causes for aquatic environment degradation.

There are four methods for stormwater quality management: pollution prevention, pollution control, land-use control, and regulatory control. Traditionally, stormwater quality control has focused on two areas: regulatory controls and drainage system outlet controls (end-of-pipe, structural BMPs). More recently, greater emphasis has been placed on the implementation of more preventative measures achieved through more comprehensive drainage system design (soft BMPs). These efforts, however, have demonstrated the need to consider water quality protection much earlier in the land use planning process than at a subdivision or site planning level.

Although the focus of this book has been on drainage outlet controls and drainage system design, even state-of-the-art passive technologies do not protect water quality and the associated ecosystems, once the imperviousness of the drainage area exceeds a threshold value of 15-25%. Beyond this, such reactive approaches are ineffective, even counter-effective, and only proactive land use planning approaches can hope to ensure adequate water quality protection and address the issue of cumulative effects.

This paper suggests some means by which opportunities for water quality protection may be preserved during land use change, through more comprehensive land use planning.

As a result, site specific measures such as drainage system design, drainage outlet controls and regulatory controls would be more effective, and costly cumulative effects could be avoided.

17.1.2 Effects of Urban Development

New urban developments impact the environment directly and indirectly. Direct impacts result in changing valued habitats through spatial impacts. Indirect impacts include increasing off-site contaminant burdens due to effluent discharges to aquatic systems (called aquatic pathways) and air emissions to the atmosphere (called air pathways).

A direct or spatial effect from urban development can occur through reconstruction, encroachment, and intrusion. A significant direct effect is the disruption or fragmentation of pathways, e.g., lost infiltration of surface to groundwater through paving of land surfaces.

An indirect or pathways effect involves the movement of water or contaminants from land use activities through atmospheric, surficial or underground hydrologic pathways to degrade water quality in areas remote from the source of degradation.

Ensuring that these pathways are maintained, and that contaminating substances are prevented from entering hydrologic pathways and degrading water quality elsewhere in the watershed, represents a considerable challenge to land use planning.

17.1.3 Settling of Ecosystem Targets

In the first paper in this book, principles of ecosystem management and sustainable development were introduced for setting ecosystem targets on a watershed basis (Hindley, 1991). The premise used was that ecosystem planning on a watershed basis is needed to seek integrated solutions for resolving land development impacts on water quality, fisheries and other valued ecosystem components.

17.1.4 Focus of this Paper

The objective of this paper is to propose environmental guidelines for land use planning which will preserve or enhance healthy ecosystems in areas of new urban development.

This paper builds upon the concepts presented in the first paper by proposing guidelines for establishing which land areas should be protected from the direct effects of urbanization by setting them aside as areas of no development. By having these guidelines established, the lands to be protected can be clearly defined. All institutions involved in the urban development process (the land owner, the proponent, the review agencies) will have a common basis for determining which lands are to be protected and the rationale for protection.

The guidelines make the assumption that one can preserve or enhance these ecosystems by preserving or enhancing the habitat of the biota of the ecosystem, i.e. the physical space where key biota of the ecosystem live and/or reproduce. These guidelines therefore define land areas in which urban construction and urban land uses are either not allowed or are significantly constrained. Such urban land uses include roadways, corridors for other services such as limited access freeways, trunk water mains and sewers, hydro right-of-ways and residential commercial and industrial buildings.

17.1.5 Environmental Features Considered in this Paper

There are a number of natural environmental features that contain key ecosystems or that are dependent upon, or which are critical to maintaining, adequate surface water quality in urban and urban fringe areas. They include: aquatic communities, in particular, fisheries; wetlands, ESAs, ANSIs and other natural features; groundwater systems; passive recreational uses; hazard lands; and agricultural lands.

For each of these, some example guidelines and criteria are proposed that would allow a large planning area to be evaluated according to the valued feature's sensitivity to land use change. In each case examples are given that emphasize the value of the feature in protecting against environmental degradation. Generically, these zones are as follows:

1. an area of no development,
2. a spatial buffer area,
3. an environmental research area,
4. area of environmentally friendly development, and
5. area requiring site planning.

In other words, 1 and 2 are development exclusion areas, while zones 4 and 5 are areas with development potential. Zone 3 may be an exclusion zone or have development potential depending on additional information.

For each environmental feature, its characteristics are first introduced followed by some management targets (called technical guidelines) and land use planning guidelines (called environmental guidelines for landuse planning).

17.2 Causes of Environmental Degradation and Methods for Control

There are several key ecosystem and human components often identified as potentially requiring protection in lands being subjected to urbanization or which are in the urban fringe. They include:

i) the assemblage of fish in the relatively pristine streams and rivers which flow through the site;

ii) the assemblage of natural land-based wildlife which use:
   - the river and stream valleys for living and as corridors,
   - the wetlands,
   - the table land woodlots, and
   - the open fields which connect the table land woodlots with the valleylands;

iii) the assemblage of birds which use the same land areas as land-based wildlife as well as:
   - the residential areas, and
   - other lands such as the landfills and aggregate extraction areas;

iv) the assemblage of bees, aphids and other insects of the food web that use both the woodlands, valleylands and stream waters as a part of their life cycle;

v) humans who inhabit the small picturesque villages, the farms and other residences in the lands subjected to urbanizing pressures.

Migratory birds use their specific land areas for their summer home for laying eggs, hatching them and rearing the newborn chicks before returning to their wintering grounds. The resident assemblage of birds use such lands as woodlots year round, as homes for winter shelter as well as breeding and rearing young.

Many kinds of land use changes lead to environmental degradation. These changes include:

- urban development;
- construction activity;
- increased water pollution control plant discharges;
- changes in agricultural runoff;
- solid waste disposal,
- sewage disposal through septic systems in rural areas;
- water taking, including drinking water supply from groundwater sources;
- aggregate extraction and quarrying of bedrock;
- other activities including:
    - atmospheric fallout,
    - industrial spills,
    - direct industrial discharges,
    - specific land uses such as golf courses and other recreational activities in valley lands,
    - channelization of headwater streams, and
    - automobile/vehicular traffic.

The focus of this book has been upon the use of lands in urbanizing areas and existing areas, and their effects upon the aquatic portion of the ecosystem, primarily surface water systems. In areas of new urban development, water quality protection involves one of four approaches:

i) pollution prevention (e.g., soft Best Management Practices);
ii) pollution control (e.g. hard or structural BMPs);
iii) land use planning; or
iv) regulatory control.

The main orientation of this book has been upon pollution control. But as Schueler (1990) notes, the evolution of urban stormwater management has evolved from flow control through quality management through riverine ecosystem management (see Table 1). With the realization that state-of-the-art structural devices do not prevent degradation of water quality and the associated ecosystem after a certain threshold of urban development (perhaps at a degree of imperviousness of 15-25%), environmental protection requires that land use planning be used as an additional water quality management tool.

TABLE 1: PROGRESSION OF URBAN STORMWATER MANAGEMENT INTO AN ECOSYSTEM PERSPECTIVE FOR STREAM PROTECTION AND RESTORATION

1. Stream Channelization
2. Flooding and Erosion Control
3. Extended Dry or Wet Ponds
4. Stream Temperature and Flow Control for Habitat Protection
5. Habitat Restoration
6. Integration of Ecosystem and Human Systems

This takes the form of:

i) site density control; and
ii) site layout planning.

While these land use planning tools are important tools for protecting water quality, they are also important tools for ecosystem management because structural BMP trains will impact the habitat of biota if placed on the edge or in the middle of the physical habitat of key biota.

17.3 Ecosystem Planning, Watershed Planning and Sustainable Development

Attempts are being made to integrate these different issues through ecosystem planning on a watershed basis, through sustainable development and by conducting research to

define threshold effects beyond which state-of-the-art BMP trains do not protect environmental quality. The integration of the three concepts: ecosystem planning, watershed planning and sustainable development planning into municipal planning processes are evolving.

A method for linking BMP planning into watershed planning and the traditional urban planning process has recently been proposed (see Figure 1 from MMM, 1990). It requires a top down approach in which watershed planning is conducted at the same time as, or ahead of review of official plans. The requirements of the process are not well understood by urban planners because, as they point out, urban development often occurs ahead of the development of watershed plans.

The terminology "sustainable development" requires that a methodology be developed which defines practical planning tools and guidelines. To accomplish this, environmental planning should define implementable environmental quality targets which can be audited to (1) demonstrate the success that forward planning can have to control the impacts on the environment and (2) indicate where modifications to the planning process are required to maintain environmental quality and allow for economic development. To transform the nebulous terminology "sustainable development" into practical guidelines, an ecosystem approach is often used as the conceptual basis for developing a comprehensive management plan and for evaluating the sensitivity of the response of the environment to a management strategy. A sketch of a watershed based ecosystem is given in Figure 2.

In Ontario, the ecosystem approach has been pioneered by the International Joint Commission and is mandated by recent agreements signed by the Provincial Government. It provides an integrative framework for describing the elements of the ecosystem, and forms the social, philosophical and ecological basis for planning and for relating man's activities to the environment. We have defined an ecosystem-based approach to planning as involving:

- the use of the various living organisms (including man) and biological niches of the watershed as the basic building blocks of the plan;

- the use of natural rates of cycling of material between water, air and land as one basis for defining unpolluted conditions;

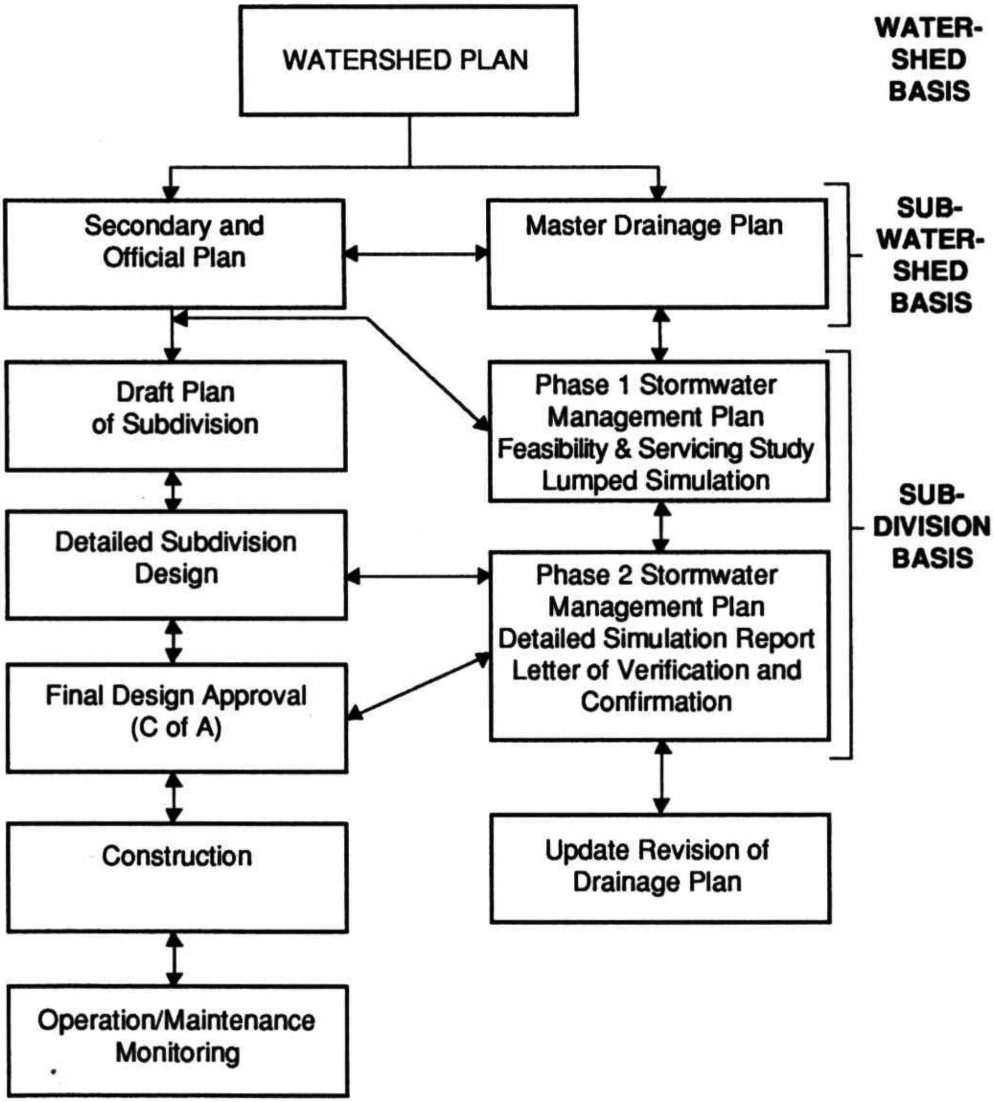

Figure 1: Urban Drainage and Land Use Planning for New Development

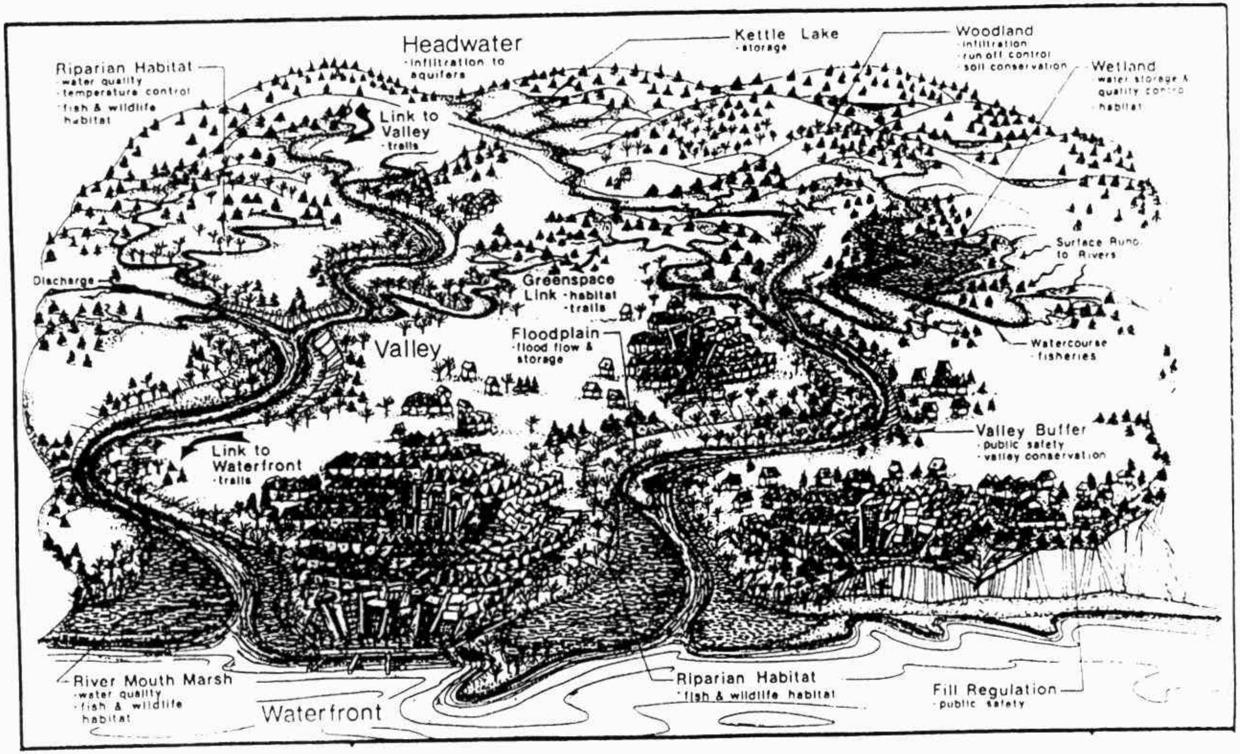

Figure 2: An Ecosystem Approach to Watershed Management

- the definition of pollution as an unbalanced ecosystem resulting from accelerated rates of cycling of matter or from the entry of toxic substances into these cycles which cannot be tolerated by particular plants or living organisms including man; and

- the concept of the ecosystem as the integrative framework for relating various human activities to the non-human parts of the ecosystem.

In simpler terms, the Crombie Commission describes an ecosystem approach as follows:

- everything is connected to everything else;
- human beings are part of nature and not separate from nature;
- human beings are responsible for their actions and associated impacts; and
- economic health and environmental health are mutually inclusive.

The major conceptual divisions developed in the Rouge River study are given in Table 2. The framework given in Table 2 for restored environmental quality was presented by Frances *et al.* (1979) for the Great Lakes Basin and adopted by the International Joint Commission for its planning. The framework attempts (i) to establish the key values of the human and natural environmental ecosystems under both regional/Great Lake scales and local watershed scales; and (ii) to provide a rational basis for examining the major concerns of economic development, human health and safety, and environmental values. The framework requires additional reshaping for any other watershed to include the key ecosystems and to further adapt it into human terms.

The major problem with concepts of sustainable development and ecosystem-based approaches to planning are to phrase/translate the global and macro requirements for protection of all the biota of a healthy ecosystem into practical, management/environmental guidelines for application to land use planning on a micro scale. A second problem is the dearth of research data which establish what biota are to be protected over what spatial scale and how these biota respond to the effects of well-planned urbanization.

TABLE 2: CONCEPTUAL DIVISIONS FOR ECOSYSTEM-BASED MANAGEMENT PLAN, USED IN ROUGE RIVER STUDY

I. Quality of Life Within Great Lakes Ecosystem

1. linkage to Great Lakes ecosystem
2. pride in Great Lakes and Rouge River ecosystem
3. balance of economic and environmental value
4. quality of life and land ownership

II. Water Quality, Public Health and Aesthetics

5. contact, non-contact recreation
6. drinking water
7. fish consumption
8. aesthetics

III. Public Safety

9. erosion and flood protection
10. risk to life in valley lands

IV Fisheries, Riparian and Terrestrial Habitats

11. river beds as fish habitat
12. angling
13. enjoyment of plants, wildlife
14. wildlife and waterfowl and their habitats

The recent compilation by Edward O. Wilson, a Harvard University specialist in social insects and campaigner for protection of endangered species, illustrates the point. He found that of the 1,032,000 known species of animals, 73 percent are insects. Less than 0.4 percent are mammals. There are so few kinds of mammals on Earth that, for example, there are 28 times as many species of butterflies and moths. There are 72 times as many kinds of beetles as kinds of mammals. Thus nature takes a decidedly broader view of who the "Lords of the Earth" really are in contrast to human beings who are mammaliocentric and who think that they are Lords of the Earth. That is, they tend to think that mammals - of which they constitute one species - are the planet's most important animal.

Humans are truly far from being the Lords of the Earth but in an urban and agricultural context, they are the dominant force for change. They are the dominant cause of environmental degradation particularly in the past two decades through (i) population growth, (ii) manipulation of the ecosystem by usage of herbicides/pesticides and erosion of the surface ecosystem with machinery, and (iii) other forces caused by economic growth.

How to reintroduce to human populations the limits posed by the ecosystem and other sustaining life forces of the planet earth, is the key question being grappled within sustainable development.

The contribution of this paper to water quality management and environmental protection is to suggest guidelines for protecting key habitats used by different biota of the ecosystem. These guidelines can be used together with future research to ascertain whether biota are protected.

These guidelines are one requirement for combining land use planning and watershed planning.

17.4 Modes of Urban Development Impact on the Environment

Ecosystems and other land uses are effected directly or indirectly by urban development. Direct effects occur through change of land use (i.e., transformation of the lands from an ecosystem to a human use). These are called spatial effects in this paper. Indirect effects

occur along pathways by transferring mass, energy or momentum from one ecosystem component to another through pathways (i.e. through the connections between ecosystems). Two other effects are social and cumulative effects.

The impact of urban development is "felt" physically through the first two modes:

i) spatial impacts (i.e., transformation of land uses); and
ii) pathways.

In the case of urban development, spatial impacts can occur through:

i) reconstruction - direct change of the land use by the construction of roads, sewers, houses, commercial and industrial buildings on a significant wildlife habitat such as a wetland;
ii) encroachment - the movement of rural residential/industrial fringe into a valued resource area;
iii) intrusion by humans - pedestrian traffic through wildlife habitat areas or by placing recreational uses into an environmentally significant area which are incompatible with maintenance of environmental attributes.

Pathways involve the movement of water or contaminants from industrial, residential, commercial or agricultural areas through atmospheric, surface water or groundwater routes to impact biota in the various ecosystems where they live, reside, breed and raise their young. These ecosystems units are called habitats.

17.4.1 Spatial Impacts

A permanent effect of urban development is the loss of natural features, valued landforms and wildlife habitats if development occurs on lands occupied by these land uses. Critical lands involving loss of natural feature/habitats include:

- ANSIs,
- Wetlands,
- ESAs,
- Valleylands,

- Woodlots, and
- Fish habitat in streams and adjoining canopy.

In addition, humans may value certain lands sufficiently to warrant their protection. Such lands include:

- Landforms, and
- Agricultural lands.

Additional lands which can be used to minimize spatial impacts include buffer areas around or setbacks from these land areas.

17.4.2 Pathways Impacts

The major impacts upon hydrological pathways include:

1. Increases in surface water flow due to the increased imperviousness of the watershed.

2. Reduction in infiltration to groundwater and the associated effects on groundwater flow and aquifer levels.

3. Increased risk of water quality degradation due to use of chemicals and fertilizers, solid waste handling and sewage disposal.

4. Increases in flooding and erosion potential due to increase in surface water runoff.

5. Habitat degradation and even habitat destruction due to erosion and siltation in rivers and streams and altered groundwater tables in wetlands.

The major impacts of biological pathways include the bioaccumulation of toxic elements through the food chain. The major effects on air pathways include increased emissions of various contaminants into air from fuel consumption for heating residences, industrial and commercial buildings, transportation, and industrial operations.

17.4.3 Social Impacts

The major social/environmental impacts include:

- noise pollution due to site activities and traffic;
- impairment of aesthetics which is dependent upon the specific land use; and
- increased risk to human safety (e.g., generation of truck traffic).

17.4.4 Cumulative Effects

The current system for reviewing planning applications, particularly in rural areas within the urbanizing fringe, is primarily orientated to site-specific analysis and, therefore, does not anticipate the broader, longer term environmental implications of permitting many individual sites to be developed. In some planning circles, these are known as cumulative environmental effects.

Presently, there appears to be four types of cumulative effects analysis being conducted in the Province of Ontario. These analyses are dependent upon the land base used to define them. They include:

- Watersheds or Subwatershed Studies,
- Ecosystem Based Planning,
- Multi-Media Effects Studies, and
- Cost Analysis for Retrofitting Existing Developments.

The first two types of studies (watershed; ecosystem based planning) allow one to examine the effect of all development upon:

- loadings of contaminants to surface water and groundwater;
- changes in groundwater and surface water flow;
- changes in an instream or lacustrine fishery habitat due to changes in surface water flow or water quality; and
- changes in other ecosystems or their habitat due to introduction of contaminants through air or water pathways.

Multi-media effects involve adding up the effects of development on all environmental media including water, soil and air. It may also include such social aspects as energy use and capital/operating costs. Various approaches may be used for conducting the evaluation including a ranking system (high, medium, low; or score 0 to 5) to form a composite rating for the major environmental media under consideration.

Studies for retrofitting existing development include internalizing the costs of externalities which are costs which accrue external to the proposed private development. Examples include (i) costs to municipality such as costs of inspection of water and sewage systems, (ii) costs to off site property owners such as contaminated groundwater affecting adjacent property owner, and (iii) costs of rebuilding roads to a new engineering standard and of garbage collection and (iv) cost of installing public water supply and sewage collection systems or smaller scale communal services in existing hamlets when development has become too dense to allow the continued use of private individual services.

Irrespective, it is important to point out that any type of a cumulative effects analysis will turn the traditional planning process (site plan approval, subdivision approval) around by being top-down. This will augment the current approach to managing urban growth which is to encourage municipalities to plan for and control urban growth through their official plans and other planning instruments by formulating a vision of what form they want urban growth ultimately to attain. To formulate a vision is, of course, quite difficult because ultimate conditions have generally not been successfully planned, even for urban areas.

17.5 Technical and Environmental Guidelines Proposed in This Paper

The proposed guidelines for environmental protection are stated below in one of two ways:

1. Environmental Guidelines for Land Use Planning
2. Technical Environmental Guidelines for Use by Other Agencies

The guidelines for land use planning are designed to protect the environment from spatial (i.e., by encroachment or, destruction of a habitat or a ground water recharge area) impacts. The technical environmental guidelines are designed to define uncertainties

associated with land use planning or to provide some additional direction for reviewing the effect upon such pathways as:

- hydrological (an effect on flow or water levels),
- water quality, and
- biological (an effect upon an instream fishery).

The environmental guidelines for land use planning are stated in one of several ways, including:

1. An Area of No Development.
2. A Spatial Buffer Area.
3. An Environmental Research Area: ERA, (i.e., a holding category) in which we need detailed studies to define appropriate land uses.
4. Area of Environmentally Friendly Development (i.e. areas where urban development can proceed, provided water quality targets for streams and groundwater are preserved.
5. An Area Requiring Site Planning - i.e., where density and location are needed to provide adequate protection

The studies required for ERAs will provide additional site specific information and additional data on other areas within the watershed. These studies may also prove that the development will have no detrimental impacts of significance to environmental resources such as groundwater, surface water, etc.

17.5.1 Guidelines for Aquatic Community (Fishery) System

17.5.1.1 Introduction

Technical guidelines and the associated environmental guidelines for land use planning should be developed for two different components of the aquatic community, namely a cold water fishery, and a warm water fishery.

Based upon our previous studies, suggested guidelines and directions for developing environmental guidelines for lands adjoining streams are proposed below.

17.5.1.2 Proposed Technical Guidelines

Four variables which require protection in order to maintain an aquatic community (fishery) are:

- Bottom Physical Habitat
- Flow regimes (percent of base flow of annual flow)
- Riparian Canopy (to maintain stream temperatures and provide organic matter as food for the biological food web) and
- Chemical Water Quality Characteristics (to prevent chronic toxicity related impairment of the fishery)

The following technical guidelines are proposed for a coldwater fishery.

1. Protect the existing habitat of native coldwater fishery.
2. Enhance the habitat of coldwater fishery where appropriate.
3. Protect the existing habitat of the migratory coldwater fishery especially where this habitat is a key part of a lake ecosystem, and
4. Where degradation of certain zones of habitat of coldwater fishery and warmwater fishery have occurred, adopt a no-net loss approach for the whole ecosystem.

17.5.1.3 Proposed Environmental Guidelines for Land Use Planning

The proposed environmental guidelines for land use planning are:

1. For streams containing a resident cold water fishery, no development shall be allowed on upstream watersheds, unless the proponent can ensure that the technical habitat requirements of cold base flow, instream canopy water quality etc. are met.

2. For streams providing habitat for a migratory coldwater fishery or a warmwater fishery, development in upstream watershed may proceed in an environmental friendly manner, provided the cumulative impacts of all forms of development are shown to maintain the technical requirements for habitat protection.

3. A designated buffer zone along either side of the stream bank is an area of no development. The joint MOE/MNR Interim Stormwater Quality Control Guidelines (see Chapter 3) propose the following buffer zone widths from the stream bank on either side of the stream:

- 15 m for a stream containing a warmwater fishery, or
- 30 m for a stream designated as containing a coldwater fishery.

Where the stream contains a resident coldwater fishery dependent upon riparian canopy, the buffer zone should be densely vegetated with trees and canopy overhanging the stream banks.

17.5.1.4 Implementation Considerations for These Proposed Land Use Planning Guidelines

These guidelines need to be assessed as to whether they would <u>work</u> (i.e. to protect the coldwater fishery) using a detailed impact assessment methodology. This would require a pathways analyses of the effect of land use change upon the flow and water quality of surface water and groundwater. It also requires that appropriate watershed and subwatershed studies be undertaken.

In addition, demonstration projects are required to show that urban areas can be built in the headwater areas of streams containing a coldwater fishery such as Brooke Trout. A key part of the demonstration project is building infiltration based BMPs which protect base flow and stream temperature.

17.5.2 Guidelines for Wetlands, ESAs, ANSIs and Other Natural Features

17.5.2.1 Introduction

Existing studies have generally designated the location of wetlands, ESAs and ANSIs in most areas of the Province. However, the botanical or hydrological significance of many of these features may need updating. For certain areas, a complete inventory may be needed since the data describing them may not adequately characterize their relevant ecological and hydrological attributes.

17.5.2.2 Proposed Technical Guidelines for Wetlands/ESAs/ANSIs

1. Valleyland Wetlands/ESAs/ANSIs

The following guidelines are proposed for a "naturalist - preservation" goal for valleyland wetlands/ESAs/ANSIs.

1. The wetlands/ESAs/ANSIs should be preserved by ensuring that residential transformation of valley lands or encroachment of other land uses (industrial areas; aggregate extraction) or intrusion (by humans) do not disturb the existing plant and animal/bird assemblage using the wetlands.

2. No net loss of wetlands should be applied to all wetlands, not just class 1 or 2 wetlands.

3. The present groundwater regimes (ground water level variations; flow of groundwater through the wetland areas of groundwater recharge) within the key wetlands should be maintained to ensure the integrity of the wetlands.

4. Surface water variations within the wetlands connected to the river/creek by surface pathways influenced by variations of river (creek) flow should be maintained within levels that the plant, wildlife and bird community can accept.

5. Leakage of contaminants into groundwater pathways which flow to wetlands/ANSIs/ESAs or direct spills of hazardous substances into these areas should be prevented.

6. Atmospheric transport of pollutants into the wetlands/ANSIs/ESAs from existing areas, from newly developed areas and from other hydrological pathways (surface water, groundwater), should be minimized to ensure that bioaccumulation of metals and synthetic organic chemicals (SOCs) in plants or birds of the wetlands are not problems, and

7. Wetlands should be restored where possible to connect wetlands with each other, with lakes, and with other natural features.

2. Tableland Wetlands

The following guidelines are proposed for Tableland Wetlands.

1. Such wetlands, where they exist, should continue to maintain their hydrological functions as groundwater recharge areas, and

2. Wetlands in the existing tableland infiltration areas recharging to groundwater pathways to coldwater streams particularly if they contain remnant populations of resident coldwater fish such as Brook Trout, should be enhanced.

3. Terrestrial Vegetated Habitat

The following guidelines are proposed for terrestrial vegetation.

1. Large woodlots of sufficient size to have interior forest conditions are candidates for preservation and/or enhancement.

2. Other woodlots or hedgerows should be assessed for preservation and or enhancement to provide links between valued habitat units.

3. Terrestrial lands or valley lands containing rare or endangered plants are candidate areas for preservation.

4. Rebuild corridors where existing hedgerows/woodlots/valley lands are not connected, if it is desired to provide a particular corridor, and

5. Woodlots or hedgerows should be assessed for use and possibly enhancement where they would provide "Green Space" in residential, commercial, industrial or parkland areas.

17.5.2.3 Proposed Environmental Guidelines for Land Use Planning

The following environmental guidelines for land use planning are proposed.

1. All wetlands rated class 1 to 3, and ESAs are areas of no development

2. Suitable buffer areas using appropriate technical criteria are to be provided to protect the core ecological and hydrological functions of these wetlands and ESAs.

3. All other wetlands (whether rated class 3 to 7 or not formally designated) are environmental research areas until their status is reviewed according to the recently developed MNR wetlands policy and the suggested technical guidelines.

4. ANSIs which have a potential ecological and hydrological function are environmental research areas, until their functions are properly clarified, and

5. Woodlots are environmental research areas until their characteristics and regional ecological functions are clarified.

17.5.3 Guidelines for Surface Water Quality and Recreation Issues

17.5.3.1 Introduction

Land use planning guidelines for surface water quality and recreational uses of surface water are generally not developed since these attributes are mainly influenced by pathways impacts of urbanization. But with the realization that threshold effects exist, planning controls (site density, site layout) and regulatory controls become increasingly important.

17.5.3.2 Proposed Technical Guidelines

The major criteria for surface water quality are technical in nature and relate to the quantity and quality of surface water runoff, the prevention of spills and the prevention of downstream erosion. Erosion may cause chronic impairment of fishery habitats.

Should stormwater control options be insufficient to assure adequate water quality, then planning controls would be necessary at a site level (i.e. site layout, site density).

For water quality in particular, watershed planning is essential. The linkage of watershed planning to land use planning shown in Figure 1. The lack of watershed planning should be considered the major limitation of land use planning.

17.5.3.3 Proposed Environmental Guidelines for Land Use Planning

The following guidelines are proposed:

1. Subwatersheds, containing undesirable threshold effects after BMPs have been used to minimize the effects of urban development, are areas requiring site planning.

2. Subwatersheds which do not contain threshold effects are areas of environmentally friendly development.

17.5.4 Guidelines for Groundwater System

17.5.4.1 Introduction

The major aquifer systems, the surficial aquifer systems, their recharge areas and their discharge areas are the fundamental resource of concern here.

17.5.4.2 Proposed Technical Guidelines

The proposed guidelines include the following.

POLLUTION CONTROL IMPLEMENTATION

1. The groundwater flow regimes of the major aquifers shall be protected from development.

2. The groundwater quality of the major aquifers shall not be degraded in a measurable way, unless a groundwater protection plan has designated otherwise.

3. No spills or persistent industrial organic chemicals shall be permitted to enter these aquifers.

4. Degradation of surficial aquifers not directly connected to these major aquifers shall be permitted but minimized to the extent possible with regard to water quality parameters (e.g., phosphorus, nitrate) that can be assimilated by the ecosystem. The degree of protection afforded shall be defined based upon the specific end uses of the water. For example, the following represents limiting factors with appropriate targets:

   - phosphorous in groundwater shall not exceed loading limits and the regulatory philosophy developed for the management of the Great Lakes, and
   - nitrate targets shall be defined by drinking water requirements

5. A comprehensive groundwater protection plan must be developed on a regional and on an aquifer basis.

17.5.4.3 Proposed Environmental Guidelines for Land Use Planning

Due to the large uncertainties associated with groundwater protection a conservative approach is suggested for the next several years, pending the outcome of several studies. The following guidelines are proposed.

1. Recharge areas or infiltration zones which communicate directly to deep aquifers used for drinking water purposes are areas of no development. The exception to this is where the proponent can demonstrate that post development infiltration rates are equivalent to pre-development rates and that aquifer water quality is not significantly impaired.

2. Recharge areas critical to maintaining water levels in wetlands or baseflow in streams continuing a resident coldwater fishery are a candidate area of no development. They may be designated as an environmental research area, until watershed/subwatershed studies are completed which establish the impact of urban development, and that the impacts are acceptable.

3. The well head protection zone designated to protect municipal well water supplies are areas of no development.

4. The following guidelines are proposed for the urbanizing fringe where private services depend upon aquifers for drinking water or where septic systems discharge to groundwater systems.

   (i) No development shall be allowed should the development adversely affect the well water levels or rate of supply to down gradient well water users. Similarly groundwater baseflows shall not be adversely affected where there is a potential or resident cold water fishery stream.

   Development may be considered as an exception to these guidelines if:

   - a comprehensive groundwater study has been completed and the development capability above the aquifer(s) have been established or
   - the downstream user is provided an alternative supply of potable water.

   (ii) Development may be allowed in "an environmentally friendly manner" upon areas where surficial aquifers lead to wetlands. Existing guidelines for nitrate concentrations in septic system discharge may be exceeded only if the aquifer outlets to a wetland which has the capacity to denitrify the groundwater.

   (iii) Development upon infiltration areas leading to surficial aquifers may be permitted if the aquifers are designated as degradation zones. These aquifers cannot be in hydrological communication with deeper regional aquifers. Down-gradient users must not be using the aquifer for drinking water purposes.

5. Special planning areas such as the Niagara Escarpment and the Oak Ridges Moraine should be designated an environmental research area for any major user of groundwater, until a comprehensive groundwater management and protection strategy has been developed.

17.5.4.4 Further Discussion of Technical Issues

A conservative approach to groundwater management is evolving in Ontario for the immediate future. Previous planning processes have not worked in the past because of failures in the following:

i) spectacular failures have been caused by industrial development polluting groundwater and causing costly remediation problems;
ii) the locations of regional aquifers have not been adequately considered;
iii) site planning has not adequately considered the cumulative effects of long term development;
iv) Targets have not been set for many areas; and
v) Auditing of the effects of development have not been undertaken. Financial commitments and operation and maintenance procedures are often not enforceable by environmental regulatory authorities.

To address these issues, a comprehensive inventory of groundwater resources and impact study of key aquifers is required. The following items are required over the long term in a groundwater implementation strategy:

1. comprehensive planning, involving land use and resource evaluation,
2. establishing targets,
3. a performance assessment of the plan,
4. enforcement of applicable standards,
5. a financial commitment and associated O&M to implement this plan, and
6. monitoring.

It is possible that the proposed environmental guidelines for land use planning with respect to the urbanizing fringe could be made less strict if:

- sewage systems with denitrification systems were installed;
- financial guarantees/performance bonds were established sufficient to remediate any problems should they occur and to prevent the conversion of approved facilities (floor drains, etc.) into non conforming uses; and
- remediation expertise is available to clean up the groundwater aquifer, should it become contaminated.

17.5.5 Guidelines for Hazard Lands

17.5.5.1 Introduction

This issue includes the following land areas:

- flood plains
- lands with steep slopes and
- active erosion areas.

Flood plains are lands susceptible to flooding which endanger human safety. Steep slopes are possible sites of developing erosion scars which endanger the safety of human residences if they are built too close to the top of the slope.

17.5.5.2 Technical Considerations

A variety of technical standards are in use for establishing the flood and fill lines and the associated buffer strip. The following may be used:

1. The flood and fill lines where they have been established by Conservation Authorities,

2. An update of these lines may be necessary as additional watershed development occurs, and

3. Appropriate widths of buffer strips as areas of no development or site planning where the location of building envelops are controlled.

Principles for establishing the width for buffer strips along fill lines should be developed to account for the slope of an embankment, its distance from the stream and other relevant factors. For regional planning purposes, a uniform width could be designated and used for initial planning purposes. However, in principal, a uniform width is not an appropriate approach because different sites may require narrower widths, while others may require a larger width.

17.5.5.3 Proposed Environmental Guidelines for Land Use Planning

The protection of human life and property protection has been codified as a standard. In simple terms, it may be summarized as:

1. No building or its associated envelop shall be constructed between the flood and fill lines.

2. An appropriate width of buffer strip outside the fill lines should be designated as an area of no development, or as an area of site planning control.

17.5.6 <u>Guidelines for Agricultural Systems</u>

17.5.6.1 Introduction

This issue describes the need to maintain high productive agricultural lands as foodlands. Developmental and economic pressures are rapidly depleting the remaining stock of highly productive agricultural lands in Ontario.

17.5.6.2 Proposed Technical Guidelines

The following guidelines have been proposed for agriculture in our previous studies:

1. Protect valued foodlands where a contiguous rural community exists to continue active farming for food production purposes, or where stewardship of conservation of foodlands could be re-established.

2. Protect valued farmland where a unique use depends upon the soils or other resources of the land.
3. Protect agricultural lands which have unique historical or cultural values.

17.5.6.3 Proposed Environmental Guidelines for Land Use Planning

The following environmental guidelines are proposed for agricultural lands in areas outside the urbanizing fringe:

1. Class 1 Agricultural lands are areas of no development; and

2. Class II and III Agricultural lands are environmental research areas, pending studies based upon the technical guidelines.

The following guidelines are proposed for agricultural lands within the urbanizing fringe.

1. Class I, II or III lands are Environmental Research Areas if they meet Technical Guideline 2 (Unique Use) or 3 (Historical/Cultural values).

2. All other lands are lands for Environmentally Friendly Development.

17.6 Consistency of These Proposed Guidelines With the Recent Provincial Policy Initiative

These proposed environmental guidelines and technical guidelines are comparable to the recent provincial initiative on the Oak Ridges Moraine (ORM).

17.6.1 <u>Background to Provincial Policy Initiation</u>

The Oak Ridges Moraine is a height of land which stretches across south-central Ontario from the Niagara Escarpment at Cataract to the Northumberland County border at Castleton (Kanter, 1990). The area is characterized by rolling and knobby terrain with numerous pockets of poorly or imperfectly drained soil. Many small ponds occur

naturally and many have been created in the poorly drained depressions on the broad crest of the moraine. In the shallower slopes of these depressions, wetlands are present.

The Moraine topography divides watersheds draining into Lake Simcoe and Lake Scugog and those draining toward Lake Ontario. The area contains the headwaters of many important stream systems on its north and south slopes, including the East Humber River (Kanter, 1990). It has been determined that baseflow and/or subsurface groundwater provide a significant portion of the total streamflow in these important headwaters and should therefore not be disrupted (Kanter, 1990). The numerous Kettle Lakes in the area are the result of large sections of glacial ice being trapped in depressions during glaciation and subsequently melting to form spring fed lakes.

Although the ORM is a unique and important natural system both in terms of terrestrial and aquatic resources, no consistent and comprehensive treatment of development proposals had been in place for the area. On July 26, 1990 the province established strategies to protect significant features of the ORM as part of the Greater Toronto Area Greenlands Strategy (GTGS).

The GTGS recommended that the Minister of Municipal Affairs declare a general expression of provincial interest for the Oak Ridges Moraine Area under section 2 of the Planning Act (Kanter, 1990). Under this general expression the Ministry of Municipal Affairs will require that the sensitivities of the ORM are adequately addressed prior to land use changes. If these conditions are not met the Minister may make a specific statutory declaration of provincial interest resulting in an Ontario Municipal Board (OMB) hearing and a final decision by Cabinet. To this effect the Ministry of Natural Resources (MNR) has taken the lead role in providing technical feedback to the Ministry of Municipal Affairs (MMA) concerning land use changes on the Moraine. The MNR, in cooperation with the MOE, conservation authorities and municipalities, has developed a proposed series of evaluation criteria and information requirements for proposed land use changes. To this effect, all proposed land use changes on the Moraine will require specific information from the proponent to assist in the review of the application. This information will be used by the MNR to assess the compatibility of proposed changes with established evaluation criteria and objectives of the GTGS. The MNR will then make recommendations to the MMA for final decisions.

The MNR has tabled implementation guidelines for the Provincial interest on the Oak Ridges Moraine Area. These guidelines specify:

- their purpose, and background
- significance and sensitivity of the Moraine
- principles of the expression of interest and
- evaluation criteria for the each principle

Principles are developed for each of the following items

- Growth and Settlement
- Ecological Integrity
- Landform Conservation
- Significant Natural Areas
- Woodlands
- Water courses and Lakes
- Highly Permeable Soils
- Groundwater Resources

17.6.2 Environmental Guidelines for Land Use Planning

Based upon our review of these principles and the guideline statements they can be divided into the following guidelines for land use planning.

1. Principles involving areas where no development is permitted
   - Significant Natural Areas

2. Principles for which development will be permitted, provided that the impact is not unacceptable
   - water courses and lakes
   - groundwater resources

3. Items having guidelines of protection/enhancement
   - Ecological integrity
   - Woodlands

4. Items requiring minimization of environmental degradation
   - landform conservation

5. Items requiring cumulative effects analysis
   - water quality
   - water quantity
   - development outside of settlement areas

6. Environmental Research Areas
   - No development will be permitted on areas with highly permeable soils until a comprehensive groundwater strategy is developed.

17.7 Implications For Land Use Planning

The above sections lead to several implications for land use planning.

1. Potential Success of Guidelines

   These proposed guidelines will assist in the implementation of water quality management in Ontario only if the following four items are addressed equally well:

   i) data gathering to define key habitants;
   ii) planning prior to development;
   iii) monitoring after development; and
   iv) policing and enforcement after development.

2. Cumulative Effects Analysis

One major point derived from this analysis, is that for a variety of environmental issues no development can be allowed until a cumulative effects analysis has been carried out for these issues.

The cumulative effects analysis must be done upfront for the anticipated level and type of development.

i) to ensure that the ecological integrity of preferred biological habitats (woodlots, ESAs, stream valleys, instream habitat for a warmwater and a coldwater fishery) and conservation of landforms and sensitive agricultural soils are maintained;

ii) to assess that the uses of downstream surface waters (riverine fishery, drinking water supply, state of eutrophication) and downgradient aquifers (baseflow for coldwater fishery zones; individual wells for drinking water supply) are not impaired by the development;

iii) to ensure that additional development and infilling does not exceed the sustainable capacity of groundwater and surface water resources such that subsequent retrofitting with communical services in the future (e.g, installation of water distribution and sanitary storm sewers) would not be required.

In addition, the tools for enforcing the planning decisions must be sufficient to maintain the land use designations in order to avoid a development being able to circumvent the intent of requiring a cumulative effects analysis.

3. Size of Land Area for Cumulative Effects Analysis

The cumulative effects analysis must encompass an appropriate area of land. A subwatershed scale (for surface water) and a regional aquifer scale (for groundwater) are the minimum scale of hydrological units which must be used. Since hydrological units do not generally correspond to political units, the planning process must be proactive to define these units and to carry out the studies. The appropriate approach to initiate the cumulative effects analysis is to work with the CA, MOE and MNR to define the hydrogeological units, once the Regional Planning Department has determined that growth/development in a particular area will be of a scale of a hamlet, industrial parks or a similar area.

4. Need for Natural Features Studies

All area municipalities should carry out natural features studies to define, for planning purposes, the location of wetlands, ESAs, valleylands, ANSIs, sensitive agricultural lands, areas of highly permeable soils, landforms requiring conservation and lands requiring the application of principles of ecological integrity. As a part of these studies, field work should be carried out to confirm, or if necessary to define, the significant ecological and hydrological functions of these features. This is particularly required for Class III to VII wetlands where information is often adequate from a provincial perspective but not from a local perspective.

Some of these studies could be carried prior to a secondary planning activity. But for overall assessment purposes and to test the guidelines proposed herein, an area wide study separate from official plan studies is more useful.

17.8 Future Required Studies: Test the Guidelines

The philosophy utilized in this study is to propose the guidelines and then to test them. In proposing the guidelines, we have attempted to

- reflect environmental needs for protection
- define leading edge guidelines,
- be rigorous, but also
- practical

The next step, then, is to test these guidelines. Testing can take two forms:

i) test with overlay mapping, the implications of these guidelines for land-use planning i.e. what are the patterns of developable lands and what are their implications for land use planning.

ii) test to ensure that the goals for environmental quality are maintained and that they will protect the issues and goal statements. Should they not maintain the desired level of environmental quality, the guidelines would need to be modified.

17.9 References

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QUESTION AND ANSWER SESSION

Sessions of the workshop were recorded. This section reproduces the questions and answer sessions verbatim with minimal editing. For a few (e.g., B. Hindley), the tape ran out, leaving the Q&A session not recorded. For others (e.g., C. Toth, D. Brierley, and C. Edmonds), there was insufficient time available).

Dale Henry's Q&A Session

Q In the Rouge Study we identified that there was something in the order of 50 stormwater management ponds built in roughly a ten year period. I am a little concerned that if we see the same approach used in some of our priority 1 streams that we will no longer have coldwater streams. How did you look at that issue?

A The interim stormwater guideline document itself was based on what we know at the present time. The urban drainage management program has outlined a strategy to deal with urban drainage. It consists of watershed plan, master drainage plan and subdivision plan. The legislative might of the interim stormwater quality control guidelines comes down to stormwater management plans. The MOE approves stormwater drainage systems because it considers stormwater as sewage and we have the approval process for that, under the Ontario Water Resources Act, Section 24. It is not a proactive approach to deal with stormwater quality management but is the only mechanism that we have at the present time.

What we suggest is the carrying out of watershed studies and master drainage plans. We are hoping that the master drainage plans, the chicken pox approach used for quantity control of one stormwater management facility per subdivision would be eliminated. We would combine a number of subdivisions into much larger tracks of areas to deal with their stormwater quality problems. In addition, the document recommends the use of best management practices and source controls. We are hoping to minimize the number of stormwater treatment facilities; however, in some cases, I am sure that one facility for small land tracks will be necessary.

QUESTION AND ANSWER SESSION

Q I guess I am not sure whether you have addressed my concern about the loss our coldwater streams.

A Are you concerned with the temperatures? We are attempting to address this issue through the development of a Stormwater Quality BMP planning and design manual. We want to minimize the thermal impact of any type of stormwater discharge through the selection of appropriate BMPs and other design features. We recognize that a thermal increase could occur through the pond-type treatment process. The document will hopefully be jointly supported by the Conservation Authorities, MNR and MOE.

Hap Thron Q&A Session

Q I wanted to ask you. You had identified two sets of priorities for control of stormwater. First, the cities by size and second is the categories or classes that you call of certain establishments. Do you envision that you will have a plan or a regulation for the cities and then you will somehow develop federal technology based regulations for these sectors that will then come into play with the plans that the city has developed sort of like your pretreatment program.

A That is certainly one of the options that we are looking at. I come from the old effluent guidelines school. I am a chemical engineer and the categorical industries characterize the process wastewater effluent. There is no reason we couldn't do something like that for stormwater. What does stormwater from steel mills look like? I mean, you may be crazy. I am not sold on the idea but we could come up with say, what does parking lot runoff look like? What do zoo lots look like or some of these others. We could do it that way and that is one of the options.

Q When you get to establishing guidelines and looking at solutions, are you going to differentiate between the first flush in combined sewer overflows and then flows beyond that or are you going to apply the guidelines to the total CSO flow?

A I need to understand the semantics. Guidelines to me mean an effluent standard. Permits would usually differentiate between, the ones I have seen for stormwater and CSOs would have some distinction between the first flush and then the rest of the discharge. We talk about that in the proposed stormwater application requirements where I believe we define the first flush as the first twenty minutes or thirty minutes. I would envision that we would have some distinction in the permits for CSOs between the first flush and the rest. If we have a justification for it and the site specific circumstances warrant.

M. Price Q&A Session

Q I am glad you brought up the Scarborough Golf Club versus the City of Scarborough case. It happens that a lot of the people that were involved in that litigation are here today and I think there are some very important points that there were not time to make and perhaps ought to be made. Particularly in relation to state-of-the-art techniques.

The argument was made that state-of-the-art techniques were used and one of the aspects that was particularly approved of by the judge was continuous modelling as opposed to event modelling and the argument was that continuous modelling is more than state-of-the-art. I think it is awfully important for everybody to realize that some of these developments have been in existence for over a generation have been proven to be workable and have been in use for a long time. For example, continuous modelling was proven as a useful design tool in 1963.

The fact is that civil engineering and municipal engineering is highly conservative in many ways and a lot of what you are taught is conservative and I think it behooves you to try to get a copy of the judgement and if any of you do not have a copy I would be more than willing to send you a copy of it because I think it is very important for your design practice. Thanks Mike.

A. None.

QUESTION AND ANSWER SESSION

W. Wichmann Q&A Session

Q. How is this multi-million dollars underground ponds, how are they going to be monitored in terms of improvement in the lake quality. Because there are many other factors also and assuming that there is not an immediate improvement on the beaches, how would you respond to this?

A With regard to the detention tank at the eastern beaches, at the present, we have about 25 days per year where the beaches are posted for being unsafe for swimming because of the violation of the recreational water quality guidelines. From our modelling, using the predictive lake model, which uses some continuous simulations, we have to determine that we install the first tank, the closings in that area at Woodbine beach should be reduced from 25 days per year to about 9 days per year. That is a serious concern that will be our gauge. As far as the Ministry is concerned, they have requested that we conduct other monitoring but we have to sit down with the Ministry and find out what exactly they have in mind in that respect.

Q One of the concerns that came out of the meetings was the potential odour that might come from these tanks. I would like to know first what was done to address this concern and secondly, was there any provision made in the design of these facilities for the removal or to allow the removal of sediment?

A Yes. The underground tank will be built in two chambers and the chamber will be fitted with a semi-automatic flushing system. There will be a water flushing system built in which has to be manually initiated after rain storm. Then it operates automatically. The flushing water will then be discharged into the Metro interceptor sewer which goes to the sewage treatment plant. The tank has a vent stack which will be built into an extension to tennis club house which is adjacent which will also hold a control room. The vent stack for that tank actually looks like a chimney for the tennis club house and when the community expressed concern about odour, we committed ourselves to install air filtration systems into the vent stack. The Ministry of Environment under the Water Resources approval process, also required that we obtain a permit under the Air Approvals Act, Regulation 8 of the Environmental Assessment Act. There is another approval which we had to obtain for air approval and this approval requires us annually to report to the Minister on the odour problem.

Thomas Schueler Q&A Session

Q How much maintenance is involved with those wet ponds to keep them that clean?

A We divide the standard maintenance into two categories. There is routine maintenance which is primarily cosmetic, grass cutting, rake clean-up, and non-routine maintenance such as sediment removal. Occasional structural repairs. Basically, the routine maintenance, we estimate, about 1% of the total capital cost of each project per year, but that is typically something that would be done anyway in the open space of a community. The larger cost is for sediment removal. That can be between 2-3% per year for the capital cost of a project which doesn't sound like much but if you do it every 25 years, what you are basically talking about is the entire capital cost of the project for sediment removal every 20 years. When you have a private homeowners maintenance, that's a real staggering maintenance, that is a real staggering one shot maintenance headache. They will typically bump it back to the municipality to do if they possibly can.

Q I think that at a previous conference, it was stated that Washington DC has a number of 3,000 or so ponds, right? You were asked whether there was a monitoring ban on water quality in the receiving water bodies and how was it demonstrated that this constantly improved the receiving water quality. I read this and the answer was at that time that this was not studied.

A We have monitored the pollutant removal efficiency of the structures that we have put in and that data are contained in our manual. It is generally pretty high. In terms of watershed wide application, it is a very good question. That is typically not done. Us yanks in the States, typically rushed to regulate, never measured what we have done after the fact. We have seen measurable improvements from the degradation that could have occurred associated with new developments in many new watersheds and we are currently in the process, I will be speaking about it tomorrow, about measuring the improvement in an urban watershed.

Q I am assuming that the cost of stormwater management in the new developments was borne by the developers or by the industry and that some of the retrofit suggestions that you were talking about were borne using public funds. Is that not a reasonable statement?

A Yes that is basically how it works. The cost for all new development controls, including sediment control and stormwater management, is borne by the developers and passed on to the homeowners. We found in some early estimates that it averages between $15 and $20 per dwelling unit as an annual cost that is passed through. Our retrofit projects are being done through a wide number of funding areas. Grants from the state, many waiver mitigation projects where for some reason, somebody has an obligation to do a waiver project or mitigation project will fund us. It is primarily done by the municipalities themselves.

Q My other part of the question is was there any concern that some of the funding of the public projects needed to go ahead at the same time as some of the restrictions on developers were being implemented. I am interested in that question simply because I am wondering whether it is very important to have these types of things being implemented together or whether you can go ahead with one and not the other?

A I think it is very important to implement controls on new developments first. Otherwise, any other investment made in retrofit or watershed restoration is counterbalanced by new impacts usually further up in the watershed. I think the first trick is to get the controls on new development in our area has taken 5-7 years to finally get the development community to accept the fact that being regulated and to accept the cost and the regulations as part of doing business. Now that we have done that, we have moved toward the retrofit stuff. We can't do that until our local governments and plan review staff and engineers have got a lot more experience in pond design. In fact, most of our retrofits are converting old drive stormwater ponds into wet extended detention ponds so we have kind of fixed up all of our old mistakes in stormwater management first.

Q We have begun to discuss the concept of wet ponds with some of municipalities and they have a very real and practical concern of course related to the long term maintenance. You suggested that it was important to reserve areas for sediment disposal on site. It has been suggested that some of that sediment would be equivalent to hazardous waste. How do you manage that situation?

A The situation has not been considered a hazardous waste because nobody has designated it as such. We have done studies and we find that it is enriched

primarily with lead, zinc, nickel and cadmium. However, it is pretty tightly bound to the sediments and nobody has in fact looked at the disposal sites where they are presently being dewatered. Usually it's land application to see if there has been migration into the groundwater. I think the one practice we have the greatest concern about is oil grit separators which are used at the parking lots to collect hydrocarbons. I showed a couple of slides of that stuff and you don't need to be a toxic biologist to think it is toxic. That stuff is difficult in disposing it right now. It is landfilled or sent to the sewage treatment plant which is pumped over, at which point it becomes the sewage treatment plant's problem. Pond sediments are not from the data I have seen, do not impress me as being a highly toxic substance. Primarily because there is so much sediment in them and the material that gets trapped tends to be tightly bound. If it has not released summer after summer to either an oxy or a high pH, it is not likely to move very far or at all after it has been applied in a land application scenario. The important thing is to reserve a space for it because 20 years after you develop an area you can bet the whole ring around it will be completely developed and getting that sediment out of the ponds is very difficult at that stage. That is what I would recommend. I guess more research is probably needed although I would be concerned about the outcome on that one.

Q I'm not so comfortable with all this one event per year. Is it a wet year, an average year, do you consider the next 25 years, since you counted the 25 events. Was all this all debated in all this political discussions which lead to this criterion? Maybe for our colleagues from Washington. I think he was very careful in his answer because he said that we see some improvement in the watershed. I know the States are much more legalistic than. We should not be more careful. We should just say well we foresee some improvements or some think we can monitor in 20 years from now. At least some of the people will be retired far from stormwater management.

A That's where the use of computer programs is just great. You can use continuous simulations and you can put 40 years of records in and you can see I want that to be the basis for my average year for the one event criteria. The other thing is we have looked at the one event in comparison to volume control as Hugh Fraser mentioned earlier. The one event translates about 98% control and if your receiver is not that sensitive, you might propose something less than that. I guess

the way the policy was drafted the choice of standard in the absence of any direction from the Ministry is up to the proponent. He has to decide what he is buying and what he wants. Until we get more direction from the Ministry, I think we want action. We are hearing that we want some action and until we get direction from the Ministry, we will have to go with proponent driven systems.

Q In some of the impoundments that you have constructed or reconstructed, were there any concerns or any special attention given to the safety of the public in and around those areas?

A Yes. When we reconstruct the ponds and add a permanent pool, we still have the design criteria to maintain the integrity of the dam for the 100 year storm. In some cases we will sacrifice a little of the two year storm control, usually just a small amount of it to get the extra water quality. It's funny when you do go back and reconstruct something, all the permits that didn't exist when you first constructed it are now applied. One of the biggest hassles with retrofitting in our area is getting permits. Many of these areas have become wetlands, dry ponds for some reason. They always become kind of soggy and now we have to get special wetland permits from our U.S. Army Core of Engineers and several state agencies to do the actual retrofitting and it takes quite a bit of time.

Q We have few wet ponds in Nova Scotia. Most of them are surrounded by 8' chain link fences. One of the prime reasons for the fences are safety and the liability for the municipality. They would like to get the fence out and open the facility for appearance purposes. With your plans, I did not see any fence or anything, how did you handle that issue?

A We don't fence our ponds and we try to minimize the water hazard through contouring. The benches, both the aquatic and the one just above the shoreline. When I was a kid and I saw a fence, I always thought there was something great behind it. Basically, I don't know how the Canadian legal system works, but fences are often an attractive nuisance. That is, if you want to know what is on the other side, and even if you have a fence, your liability is not eliminated in our highly legal system in the States. I think what has really worked is there has been to my knowledge to spite having thousands of these facilities, no recorded accidental drownings in the Washington area. Even though people drown in the

Potomac River all the time and they drown swimming in quarry ponds all the time. I guess we just have not been sued yet and that is why we don't have fences.

Kevin Loughborough Q&A Session

Q On the beach closures which is done on bacterial counts, it normally takes a couple of days to get the sample analysed. The frequency of storms in this area in the summer is on the average of about 1 every 3 days. This seems to me to mean that we are ensuring that the swimmers swim in polluted water and when the water is clean, we get them out of there. Because there is a lag that is the same time as the frequency of the overflows. Now it seems to me that when the lawyers wake up to that we can expect a lot of litigation. The system is ensuring that people swim in dirty water. My question to you is: are these practices that you are doing, increasing the risk of litigation? Are you increasing your exposure or not?

A Actually, the proposed policy is that the CSO be limited to one event per year. Not every three days. I really don't see how you can come to the conclusion that we are going to increase pollution. The release from the detention facilities is not to the waterfront. The release from the detention facilities is for treatment at the main treatment plant. In fact, these pollutants are being diverted from swimming areas to the treatment plant.

We have the 48 hour rainfall rule whereby all beaches are closed for 48 hours after rainfall so that takes care of that part. As far as the sampling is concerned, there is a series of samples taken and the geometric mean is calculated and I don't know all the details of that. It is not an individual sample which decides whether a beach is going to be posted or not.

Q Question for Wichmann & Schueler -- What capabilities and what priorities have you given towards active disinfection of any effluents with respect to the detention facilities Werner, and Tom, with respect to the treatment of bacteria or viruses or whatever in your area?

A Schueler - That's one real difference between us and you guys. We don't really control for bacteria. It's primarily sediment, nutrients and trace metals and for instream protection. We find our sampling that in dry and wet weather, in rural, urban, suburban areas, that we consistently violate our standards. I think also in the States there is less reliance on fecal coliform as indicator of pathogenic viruses. For some reason we are worried about everything but bacteria. We don't do a lot of disinfection and where we do it at our treatment plants, there is probably a greater concern about the impact of chlorination than we do for dechlorination. It is just a difference in philosophy.

Wichmann - The tank facilities which we are proposing at the eastern beaches will have an overflow occurrence of about once during the summer time and we are not contemplating to use disinfection for this one overflow event.

Wisner Q&A Session

Q What maintenance provisions did you make for the detention ponds that you designed?

A This is a very interesting question. You know in the Washington manual, for instance, I have seen it can be up to 2% of the bay area of the construction cost. 1%, 2% and so on. Now you have to capitalize this over a number of fears. My feeling is that it can go to 40% and these are numbers which I actually found in one of the papers at a conference in the U.S. If we will include in this the cost of retrofitting, or polishing the pond, because I think we are at the point - why do we monitor in the end.

Why should we monitor a pond. I think we should monitor to improve it. If we include in this the possibility of building a berm or a baffle in a pond I put in this table up to 100%. I think to be safe because the municipalities need some funds to do these jobs later on. Otherwise, like I was told by Scarborough, John Tran, the monitoring exhibition re quality and so on. So what? First of all, they need the money to interpret the monitoring. Secondly, if the monitoring will give, if the performance is not very good, they need money to improve the pond performance. Where are they going to take this money from? I think we have to

have, once we built such a facility, we have to get into the economics also the cost and some more detailed studies are required about this. I would like to be clear. I am not against the concept because it is one of the good solutions but I think we should be realistic about our expectations and about the cost of the exercise. Once we are realistic, we can do a much better job with it.

GLOSSARY OF TERMS

This glossary has been largely abstracted and collated from several MOE reports, two of which were used extensively as background for this book, particularly: *Technical guidelines for preparing a pollution control plan* (MOE, 1987) and *Water management - goals, policies, objectives and implementation procedures* (MOE, 1984).

Advanced treatment - process or method for supplementary treatment of sewage and other wastes beyond the quality achieved by conventional secondary treatment.

Application factor - the ratio of the maximum concentration having no negative effect on the test organisms, to the 96-hour LC50 concentration.

Artificial aeration - a lake management technique used in waterbodies with low concentrations of dissolved oxygen to increase dissolved oxygen levels and to improve fish food organism productivity and to reduce anoxic odours.

Assimilative capacity - the ability of a waterbody to transform and/or incorporate substances (e.g. nutrients) by the ecosystem, such that the water quality does not degrade below a predetermined level.

Bioaccumulation - the uptake and retention of contaminants by an organism from its environment.

Bioassay - a determination of a concentration or dose of a given material necessary to affect a test organism under stated conditions.

Biota - the combined fauna and flora of any geographical area of geological period.

Catchment - surface drainage area.

Chemical materials - substances obtained by or used in processes in industry and agriculture; including heavy metals, salts, petroleum products and radio-active wastes.

GLOSSARY OF TERMS

Cold water fishery - a fresh water, mixed fish population, including some salmonids.

Combined sewer - a sewer intended to carry surface runoff, sewage and industrial wastes allowed by sewer by-laws.

Combined sewer overflow - flow from a combined sewer, in excess of the sewer capacity, that is discharged into a receiving water.

Conservative pollutant - a pollutant that retains one form in the receiving water (e.g. chloride, sodium, phosphorus, etc.).

Cost-effective - providing the optimum effect at the most reasonable cost.

Criterion, water quality - same as *water quality objective.*

Cumulative - brought about or increased in strength by successive additions.

Design storm - a rainfall of specified amount, intensity, duration, pattern over time, and to which a frequency is assigned, used as a design basis.

Detention - the slowing, dampening, or attenuating of flows either entering the sewer system or within the sewer system, by temporarily holding the water on a surface area, in a storage basin, or within the sewer itself.

Effluent - the wastewater discharged to a receiving water body following sewage treatment and/or industrial processing.

Erosion - the processes by which the ground surface is worn away by the action of wind and water; also the process by which the bed and banks of a stream collapse and/or are worn away by the action of water.

Equalization - the averaging (or method for averaging) of variations in flow and composition of a liquid.

Eutrophication - the progressive enrichment of surface waters, particularly non-flowing bodies of water such as lakes and ponds, with dissolved nutrients, such as phosphorus and nitrogen compounds, which accelerate the growth of algae and higher forms of plant life and result in the utilization of the usable oxygen content of the waters at the expense of other aquatic life forms.

Exfiltration - the escape of water from a water main or sewage from a sewer, into subsurface materials due to a break, leaks, etc., in the pipe; also the flow of groundwater into ditches and channels.

Fauna - the animals living within a given area or environment or during a stated period.

First flush - the condition, often occurring in storm sewer discharges and combined sewer overflows, in which an unusually high pollution load is carried in the first portion of the discharge or overflow.

Flood plain - the area of ground along a stream course that is covered by water at flood stage.

Forested areas - includes those regions of the basin where the dominant activity is directed towards the continued lifecycle of trees both deciduous and coniferous.

Foundation drain - a pipe or series of pipes that collects water drained from the foundation of footing of structures and discharges these waters into sanitary, combined or storm sewers or to other points of disposal, for the purpose of draining unwanted waters away from such structures.

Geometric mean - the antilog of the mean of the log transformed data.

Guideline - any suggestion, rule, etc., that guides or directs.

Goal - an aim or objective towards which to strive; it may represent an ideal condition that is difficult, if not impossible to attain economically.

GLOSSARY OF TERMS

Hazardous substances - chemicals considered to be a threat to man in the environment, including substances which (individually or in combination with other substances) can cause death, disease including cancer, behavioral abnormalities, genetic mutations, physiological malfunctions or physical deformities.

Hypolimnion - the region of a body of water extending below the thermocline to the bottom of the lake and thus removed from much of the surface influence.

Infiltration - the seepage in dry or wet weather or both of groundwater or vadose water into any sewer (storm, sanitary, combined). Generally, infiltration enters through cracked pipes, poor pipe joints or cracked or poorly jointed manholes; also the loss of surface runoff into pervious ground.

Inflow-Infiltration (I/I) - inflow is defined as the gross influx of wet weather flows into a sanitary sewer. Sources of inflow include roof leaders, cross-connections (storm to sanitary) and directly connected catch basins.

Lethal - involving a stimulus or effect causing death directly.

Liquid waste disposal - the application of municipal and industrial wastewater effluents such as sewage sludge, industrial effluents and sludges and wastewaters from individual home waste treatment systems to land.

Major system - the route followed by storm runoff when the minor system is either inoperative or inadequate. It generally should consist of roads and major drainage channels.

Median lethal concentration (LC50) - the concentration of a test material that causes death to 50 percent of a population within a given time period.

Micrograms per litre - (μg/L) and milligrams per litre (mg/L) - units of measure expressing the concentration of a substance in a solution.

Minor system - the drainage pipes, roadway gutters, enclosed conduits, and roof leader connections designed to convey runoff from frequent, less intense storms, to eliminate or minimize inconvenience in the area to be developed.

Mixing zone - an area of water contiguous to a point source, where exceptions to water quality objectives and conditions otherwise applicable to the receiving water, may be granted.

Non-conservative pollutant - a pollutant that can exist in more than one form (e.g., nitrogen, BOD_5, etc.).

Non-point source - an area from which pollutants are exported in a manner not compatible with practical means of pollutant removal (e.g., crop lands).

Nutrients - for the purpose of this book, this term is restricted to a description of the primary nutrients, nitrogen and phosphorus.

Objective, water quality - a designated concentration of a constituent, based on scientific judgements, that, when not exceeded will protect an organism, a community of organisms, or a prescribed water use with an adequate degree of safety.

Pesticides - an agent (usually a chemical) used to destroy or inhibit undesirable plants, fungi, animals (vertebrate and invertebrate) and bacteria.

Physical-chemical treatment process - means of treatment in which the removal of pollutants is brought about primarily by chemical clarification in conjunction with physical processes.

Pollutant - dredged soil, solid waste, incinerator residue, sewage, garbage, sludge, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, dirt and industrial, municipal and agricultural waste discharged into water.

Primary treatment - process or methods that serve as the first stage treatment of sewage and other wastes, intended to remove suspended and settleable solids by gravity and sedimentation. It provides no changes in dissolved and colloidal matter in the sewage or waste flow.

GLOSSARY OF TERMS

Rational method - coarse means of estimating storm drainage flow rates using formula Q = CIA, where C is a coefficient describing the proportion of rainfall expected to run off based on the physical characteristics of the drainage area, I is the rainfall intensity and A is the area (it has no valid basis - editor's note).

Recreational areas - the use of land and water resources for rest, relaxation and recuperation, including a variety of sports and other activities on public and private lands so designated for that purpose; including parks, cottage subdivisions, high-density, non-sewered residential areas, intensive recreational land use, ski slopes and recreational beaches.

Regulation - a specific law that legally applies in all relevant situations.

Reserve capacity - a portion of the assimilative capacity of a stream, which is set aside to provide an adequate margin of protection, including consideration for future water uses.

Retention - the prevention of runoff from entering the sewer system by storing on a surface area or in a storage basin.

Roof leader - a drain or pipe that conducts storm water from the roof of a structure, downward and into a sewer for removal from the property, or onto or into the ground for disposal by seepage.

Runoff - that portion of the precipitation on a drainage area that is discharged from the area into stream channels.

Runoff coefficient - fraction of total rainfall that appears as total runoff volume after subtracting depression storage and interception. Typically supposed to account for infiltration into ground and evaporation.

Sanitary sewer - a sewer that carries liquid and water-borne wastes from residences, commercial buildings, industrial plants, and institutions, together with relatively low quantities of ground, storm, and surface waters that are not admitted intentionally.

Secondary treatment - processes or methods for the supplemental treatment of sewage and other wastes, usually following primary treatment, to effect additional improvement in the quality of the treated wastes by biological means of various types.

Sediment - soils or other surface materials transported by wind or water as a result of erosion.

Sedimentation - the process of subsidence and deposition of suspended matter carried by water, sewage, or other liquids, by gravity.

Sewershed - the area of a municipality served by a given sewer network. For example, the area tributary to a given combined sewer overflow or a given WPCP would be termed the sewershed tributary to the overflow or WPCP.

Simulation - representation of physical systems and phenomena by mathematical models.

Solid waste disposal - the disposal of municipal solid waste from residential, commercial and industrial activities, either in sanitary landfill sites or in other forms of disposal.

Storm sewer - a sewer that carries storm water and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial water.

Storm sewer discharge - flow from a storm sewer that is discharged into a receiving water.

Stormwater - water resulting from precipitation which either percolates into the soil, runs off freely from the surface, or is captured by storm sewer, combined sewer, and to a limited degree, sanitary sewer facilities.

Sub-lethal - involving a stimulus below the level that causes death.

Surcharge - the flow condition occurring in closed conduits when the sewer is pressurized or the hydraulic grade line is above the crown of the sewer.

GLOSSARY OF TERMS

Synergism - interactions of two or more substances or organisms producing a result such that the total effect is greater than the sum of the individual effects.

Tertiary treatment - same meaning as advanced treatment.

Transportation - the movement of people and goods for social and economic purposes involving the use of machines or equipment including highways and roads, railroads, airports and utility corridors (transmission lines, pipelines).

Urban drainage or urban drainage system - includes both man-made and natural elements. An urban drainage network usually consists of two separate systems: sanitary and storm sewers.

Urbanized area - central city, or cities, and surrounding closely settled territory. Central city (cities) have populations of 50,000 or more. Peripheral areas with a population density of one person per acre or more are included (United States city definition).

Urban runoff - surface runoff from an urban drainage area that reaches a stream or other body of water or a sewer.

Warm water fishery - a fresh water, mixed fish population with no salmonids.

Wastes - for our purposes, waste means any solid, liquid, gas, odour, heat, sound, vibration, radiation or combination of any of these resulting directly or indirectly from the activities of man which may: impair the quality of the natural environment for any use that can be made of it; cause injury or damage to property or to plant or animal life; cause harm or material discomfort to any person; adversely affect the health or impair the safety of any person; or render any property or plant or animal life unfit for use by man.

Watershed - the region drained by or contributing water to a stream, lake, or other body of water.

Water table - the upper level of the free groundwater in a zone of saturation, except when separated from underlying groundwater by unsaturated material.

Water treatment/water purification - the processes or method by which "raw" water is treated to remove bacteria, and possible algae, colour, suspended material or other impurities in order to meet the minimum water quality objectives for human consumption.

Weed harvesting - the mechanical cutting of aquatic macrophytes and subsequent removal of the detritus from the water body.

Wet weather flow - a combination of dry weather flows, infiltration and inflow which occurs as a result of rain and storms.

Zone of passage - in river systems, reservoirs, lakes, estuaries, and coastal waters, zones of passage are continuous water routes of sufficient volume, area, and quality to allow passage of free-swimming and drifting organisms so that no significant effects are produced on the populations.

KEY TO ABBREVIATIONS

Many expressions recur frequently in the text, and where helpful, abbreviations are substituted. Typical examples are well-known acronyms, names of computer programs, pollutants or chemical terms, variables and trade names. In some cases further explanations are included in the Glossary of Terms.

ACRONYMS

AES	Atmospheric Environment Service
ASCE	American Society of Civil Engineers
BAT	Best Available Technology
BMP	Best Management Practice
CCIW	Canada Centre for Inland Waters
CSO	Combined Sewer Overflow
DWF	Dry Weather Flow
EA	Environmental Assessment
EFW	Energy From Waste
EMC	Event Mean Concentration
EMPPL	Effluent Monitoring Priority Pollutant list
EPA	Environmental Protection Agency (US)
IJC	International Joint Commission
MEA	Municipal Engineering Association
MISA	Municipal-Industrial Strategy for Abatement
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
MOH	Medical Officer of Health or Ministry of Health
MOT	Ministry of Transportation
MSP	Monitoring and Sampling Program
MWCOG	Metropolitan Washington Council of Governments
NIMBY	Not In My Background
NURP	National Urban Runoff Program (US)
NWS	National Weather Service

KEY TO ABBREVIATIONS

OWRA	Ontario Water Resources Act
PAC	Public Advisory Committee
PCP	Pollution Control Plan
POTW	Publicly Owned Treatment Works
PPEC	Provincial Project Evaluation Committee
PR	Public Relations
PWQO	Provincial Water Quality Objectives
RAP	Remedial Action Plan
RFP	Request for Proposal
SCAPCP	St. Catharines Area Pollution Control Plan
SWQC	Stormwater Quality Control
STP	Sewage Treatment Plant
TAWMS	Toronto Area Watershed Management Study
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WPCP	Water Pollution Control Plant
WWF	Wet Weather Flow
WWTP	Waste Water Treatment Plant

COMPUTER PROGRAMS

CREAMS	Chemicals Runoff and Erosion from Agricultural Management Systems
EXAMS	Exposure Analysis Modelling System
GAMES	Guelph Agricultural Model for Erosion and Sedimentation
HSPF	Hydrological Simulation Program Fortran
SIMS	Sewer Inventory Maintenance System
STORM	Storage and Treatment Overflow and Runoff Model
SWMM	Storm Water Management Model
WIMS	Water Inventory Maintenance System

POLLUTANTS

BOD_5	Biological Oxygen Demand at 5 Days
DD	Dust and Dirt
DDT	Dichlorodiphenyltrichloroethane (organic pesticide)

DO	Dissolved Oxygen
FC/FCOLI	Fecal coliforms
NO_3N	Nitrate Nitrogen
PAHs	Polycyclic Aromatic Hydrocarbons
PBB	Polybrominated Biphenyl
PCB	Polychlorinated Biphenyl
pH	Measure of acidity/alkalinity
PERC	Perchloroethylene (dry cleaning solvent)
SS	Suspended Solids
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOD	Total Oxygen Demand
TSS	Total Suspended Solids

SUBJECT INDEX

Editor's note: This index is not exhaustive and should be used only as a first guide to finding the required reference.

A

B

C

SUBJECT INDEX

D

E

F

G

H

I

L

M

N

O

SUBJECT INDEX